NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM 1347

REPORT ON THE SPECIAL FIELD "INTERFERENCE" TO THE WIND-TUNNEL COMMITTEE IN FEBRUARY 1945

By H. Schlichting

Translation of "Bericht über das Fachgebiet Interferenz vor dem Windkanalausschuss im Februar 1945." Aerodynamisches Institut der Technischen Hochschule Braunschweig, Bericht 45/4.

NACA

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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REPORT ON THE SPECIAL FIELD "INTERFERENCE" TO THE WIND-TUNNEL COMMITTEE IN FEBRUARY 1945*

By H. Schlichting

I. INTRODUCTION

I made the last report on my special field "Interference" at the meeting of the wind-tunnel committee in Bad Eilsen on July 27, 1943. As I explained then, my field can be subdivided into the two main parts: interference for the drag problem, and interference for the remaining aerodynamic forces of the airplane. The first is of significance almost exclusively for the flying performances; the second, for the flight characteristics. Demarcation of my special field with respect to various others is not quite simple. I have arranged with Dr. Küchemann, who represents the field "special power plants", that all problems concerning the mutual interference of TL power plants and the airplane will be taken up by him. Of the Göttingen program for investigations of TL power plants, formerly set up by Dr. Küchemann (on October 12, 1943), an essential part has meanwhile been terminated. Pure drag interference is essentially being investigated by Dr. Hörner (special field: drag). I, myself, have therefore given most of my attention to the interference phenomena for the remaining aerodynamic forces on the airplane. A great many points of contact with the two special fields, longitudinal stability (Multhopp) and directional stability (Mathias), have been found to exist.

Following, I want to report briefly, first, on the state of current investigations which had been started at the time of my last report, then advise you on recently concluded investigations. Finally, I should like to report on investigations newly started during the last year and a half, and to add suggestions for further investigations.

II. STATE OF THE INVESTIGATIONS BEGUN BEFORE THE LAST REPORT

1. For several years a very extensive aerodynamic-center program has been in progress at the DVL. The tests have the purpose of ascertaining the aerodynamic center about the transverse and vertical axis

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*"Bericht über das Fachgebiet Interferenz vor dem Windkanalausschuss im Februar 1945." Aerodynamisches Institut der Technischen Hochschule Braunschweig, Bericht 45/4.

for wing-fuselage arrangements which are largely adapted to practical conditions. The fuselage measurements have been published as partial results in the FB 1516 and 1586. Further results have not been made known so far; however, all measurements are to be published shortly.

2. At the AVA in the wind tunnel Amsterdam, an extensive investigation of pressure-distribution measurements on combinations, wing + fuselage + nacelles in the arrangements, low-, mid, and shoulder-wing monoplane has been started about 2 years ago (fig. 1). The measurements themselves have been begun but have been interrupted by the events of war in September 1944.

3. At the LFA tunnel A1, a fairly extensive program regarding six-component measurements on wing-fuselage combinations (fig. 2) has been worked on likewise for several years. These measurements which resulted from an industrial commission are similar to the interference measurements performed at the Aerodynamic Institute of the Technical Academy Braunschweig (AITHB). All combinations are shoulder-wing monoplane arrangements. On the basis of the results from the AITHB, the program later was shortened, compared to the original one. The measurements have not yet been concluded; a report has not yet been published.

4. At the AVA in tunnel A6 an interference program of wing-fuselage arrangements has been started about 2 years ago (fig. 3) which originally was planned as a three-component measurement but has recently also been carried out as a six-component measurement. A fuselage with three different thick rectangular wings in the arrangements, low-, mid, and shoulder-wing monoplane was measured. The Re number was 2.6×10^6. The measurements have been terminated and a report is to appear shortly.

5. Likewise, for about 2 years, a series of drag measurements at high speed on combinations of wing, fuselage, and nacelles (fig. 4) has been running in the LFA tunnel A2. The measurements have been approved by the wind-tunnel committee only a short while ago. They are being started at present.

6. About 3 years ago, extensive-measuring series of six-component measurements on a sectional complete model (fig. 5) was performed at the AITHB. The purpose was a systematic investigation of the stability coefficients with addition of the tail unit, after extensive measurements had been carried out before without tail unit. The measurements have been terminated and the report has been published as a preprint for the yearbook 1943 of the German Aviation Research (ref. 1).

7. The extensive systematic six-component measurements on wing-fuselage arrangements of the AITHB which were made first on wings without sweepback (ref. 2), have been extended to wing-fuselage arrangements with sweptback wings (fig. 6). To the arrangements

with wings without sweepback (rectangular and two trapezoidal wings) three forward-swept wings with constant chord with $\varphi = 15^\circ$, 30°, and 45°, furthermore a pronouncedly tapered trapezoidal wing with pronounced sweepback ($\varphi = 45^\circ$) were added. All models were measured in low-, mid, and shoulder-wing monoplane arrangements as six-component measurements (refs. 3 and 4). I might mention as an essential result that the stability coefficients of rolling moment and yawing moment are only to a small degree dependent on the plan form of the arrow-type wing (figs. 7 and 8). Figure 7 shows the additional contribution of the fuselage to the rolling moment due to sideslip as a function of the sweepback angle and of the taper. One recognizes that it varies with both comparatively little. Figure 8 shows the total yawing moment of wing plus fuselage. Here the arrangements with pronounced sweepback are somewhat more unstable than those with less pronounced sweepback. This is caused by the position of the moment reference axis which lies further toward the rear in case of strongly sweptback wings.

8. Systematic pressure-distribution measurements on wing-fuselage combinations also have been made for several years in the AITHB. The model dimensions are the same as in the former force measurements (fig. 5). There exists a certain relatedness to the AVA program mentioned in paragraph 2. The arrangements are low- and high-wing monoplanes without penetration as well as low-, mid, and shoulder-wing monoplanes. The two first arrangements (without penetration) have been measured also for unsymmetrical approach flow. The rest only for symmetrical approach flow. The rather extensive program is concluded and described in five partial and two summarizing reports (refs. 5 and 6). Figure 9 shows a result from these measurements, namely, the distribution of the local lift coefficients along the span for the arrangements low-, mid, shoulder-, and high-wing monoplane. For the arrangements with penetration, the break in the lift distribution is greatest for the low-wing monoplane, smallest for the shoulder-wing monoplane. This is of high importance for the effectiveness of the elevator unit situated behind the break.

III. INVESTIGATIONS CONCLUDED SINCE THE LAST REPORT

Since my last report, $1\frac{1}{2}$ years ago, a number of further investigations dealing with this field of problems have been made, which partly have already been terminated. They will be briefly mentioned here and enumerated from the viewpoint: coefficients of longitudinal and of directional stability.

1. A contribution to the problem of longitudinal stability is made by measurements in the wind tunnel of the Technical Academy Graz which were carried out in connection with the Braunschweig interference measurements. Whereas the Braunschweig measurements on complete models (see

section II, 6) were performed merely on a model with rectangular wing without sweepback and a rotationally symmetrical fuselage, in Graz additional measurements, have been made also on complete models, with a three-axial ellipsoid as the fuselage, and with a rectangular wing, and with a trapezoidal one with pronounced taper (ref. 7). These measurements have been concluded. A preliminary report exists and will be published shortly as an FB. Unfortunately, several supplementary measurements which had been planned could not be carried out because the Graz tunnel was considerably damaged by enemy action.

Figure 10 shows a rather interesting result from these measurements: the displacement of the neutral point of stability about the transverse axis by the elevator unit. The fuselage is the three-axial ellipsoid; a rectangular wing without sweepback and a trapizoidal wing $z = 0.2$ were used as the wing; the tail unit was, selectively, a one- or twin-keel arrangement. The very considerable difference in the displacement of the aerodynamic center by the tail unit for the arrangements low- and shoulder-wing monoplane is striking, particularly for the trapezoidal wing. The explanation most probably lies in the fact that the break in the wing lift distribution which is only very slight and the considerable fuselage lifts for the shoulder-wing monoplane produce very large downwash angles in the region behind the fuselage and thus very greatly reduce the effectiveness of the elevator unit.

2. Within the scope of industry commissions, three- and six-component measurements on wing-fuselage arrangements with very small wings and for far rearward position of the wing on the fuselage have been performed at the AITHB. By enlarging them the industry programs were complemented into systematic measurements. Figure 11 shows a remarkable result of these measurements: the displacement of the neutral point by the fuselage effect for various rearward positions of the wing and various ratios of wing size to fuselage size. In extreme cases there results aerodynamic-center displacements in the order of magnitude of 50 percent of the wing chord. The measurements have been compared with the simple theory of Multhopp. As figure 11 shows, the agreement is quite satisfactory (ref. 8).

3. When our earlier interference measurements on wing-fuselage arrangements were extended to sweptback wings, a rather interesting result was found concerning the stability about the transverse axis, namely, that the destabilizing aerodynamic-center displacement by the fuselage effect is for rearward-swept wings considerably smaller and for forward-swept wings considerably larger than for the wing without sweepback. Figure 12 shows a measuring result from a report by Möller (ref. 9). The wing-fuselage arrangements are all midwing monoplanes; the rearward position of the wing on the fuselage is measured from the geometric neutral point of the wing. In the present example the displacement of the aerodynamic center is, for the wing without sweepback,

8 percent of the geometric mean-wing chord toward the front; for the wing with 30° forward sweep, it is about 15 percent toward the front, and for the wing with 45° sweepback, 1 percent toward the rear.

4. On the mutual interference of fuselage, elevator unit, and rudder unit extensive systematic measurements have been performed at the firm Junkers (ref. 10). The effect of the geometric arrangement of fuselage, elevator, and rudder unit on the coefficients $\partial c_{aH}/\partial \alpha_H$, $\partial c_{aH}/\partial \eta$, $\partial c_{aS}/\partial \beta$, and $\partial c_{aS}/\partial \zeta$ was determined there. These coefficients give the stabilizing and destabilizing effect of the tail units.

Regarding the problem of directional stability the following new investigations exist:

5. Extensive systematic measurements concerning the induced cross wind have been carried out at the AITHB (ref. 11). Figure 13 shows a result from these measurements, namely, the yawing moment due to sideslip of three complete models which differ only in that the wing is situated at different heights of the fuselage. The difference in the contribution of the rudder unit to the directional stability is extraordinarily large. Besides the force measurements, direction measurements for the induced cross wind were performed (fig. 14); these give information on the great local difference in the effectiveness of the rudder unit.

6. The great destabilizing effect of a shoulder-wing arrangement on the directional stability must, naturally, exist also for engine nacelles and thus particularly for a twin-engine airplane with a twin-keel rudder unit. The former theoretical calculation (FB 1745) regarding the induced cross wind of a wing-fuselage arrangement was extended to arrangements wing + fuselage + two nacelles (ref. 12). Figure 15 shows a result of these theoretical calculations. Behind the engine nacelles where normally the twin-keel rudder unit is situated, zones with very slight effectiveness of the rudder unit result. These theoretical calculations were checked by systematic measurements; two-engine nacelles were added to the former models (ref. 13). Figure 16 shows a result of these measurements in comparison with the theoretical calculations mentioned. The agreement is satisfactory.

7. The effect of a jet nacelle attached to the wing on the stability coefficients is of a character similar to that of the fuselage effect in shoulder-wing monoplane arrangement. Measurements regarding this problem were carried out at the AVA (ref. 14), figure 17, for various arrangements of the jet nacelle (variation in the rearward position of the nacelle and in fillet). The difference between the various arrangements of the jet nacelle is in most cases slight.

8. The lift distribution on an elevator unit with twin-keel rudder unit in sideslip shows peculiarities which have been known for some time and have now been investigated in detail in a report by Schmitz (ref. 15). In sideslip the rudder unit, when attached unsymmetrically with respect to the elevator unit, induces very strong additional lifts on the elevator unit which produce a large rolling moment. The amount of this rolling moment is a multiple of that of the rudder unit. A simple theoretical estimate by Schmitz shows good agreement with the measurements.

IV. INVESTIGATIONS STARTED SINCE THE LAST REPORT AND SUGGESTIONS FOR FURTHER MEASUREMENTS

The suggestions for new tests to several of which have been started may be subdivided according to the following viewpoints:

A. "Scale test" (Reynolds number)

B. Measurements complementary to the interference measurements made so far on wing + fuselage + tail unit

C. Downwash and cross-wind measurements on wing-fuselage combinations

D. Measurements on wing-fuselage—tail-unit arrangements with swept-back wings

A. "Scale Test" (Reynolds Number)

So far all six-component measurements concerning interference of the airplane elements have been performed at small Reynolds numbers. In order to make them applicable to full-scale design it is absolutely necessary to carry out some comparative measurements at maximum Reynolds numbers. I have been pointing out the necessity of these tests for several years; however, the wind-tunnel committee repeatedly rejected them. Recently, these tests have been pointed out by others as well (see discussion, directional stability, Bad Eilsen on November 15, 1944). They are now to be carried out in the LFA tunnel A3, however, on several arrangements for which the measurements at small Reynolds numbers do not yet exist. These latter are then to be supplemented in the wind tunnel of the AITHB when required.

B. Measurements Supplementary to the Interference Measurements Carried Out on Wing + Fuselage + Tail Unit

It has sometimes been held against the Braunschweig interference measurements that fuselage shapes were used which rather strongly deviate from practical ones (location of maximum thickness at 50 percent, in most cases, ellipsoid of revolution). Furthermore, the variety in shape of the fuselage cross sections investigated so far is not sufficient to satisfy all practical needs. Finally, an important parameter, the mutual inclination of wing and fuselage, has not yet been investigated. Thus the following tests are suggested as supplements to the Braunschweig interference measurements:

1. Supplementary measurements on wing + fuselage and partly also on wing + fuselage + tail unit with two further fuselage shapes. (Fuselages III and IV, fig. 8.)

2. Additional measurements on wing + fuselage for two fuselages with special cross-sectional shape (fuselages V and VI, pear shaped and rectangular cross section). The combinations contemplated are compiled in figure 19.

3. Investigation of the effect of the mutual inclination of wing and fuselage on lateral force, rolling moment, and yawing moment. Six-component measurements on wing + fuselage and wing + fuselage + tail unit.

The first two measurements suggested have already been started, but not the third one.

C. Downwash and Cross Wind Measurements on Wing-Fuselage Combinations

The Graz measurements mentioned before showed an unexpectedly large influence of a high position of the wing (on the fuselage) on the stability contribution of the elevator unit. According to this, a very strong interference must exist between wing + fuselage on one hand and elevator unit on the other, which probably is caused mainly by the downwash and to a lesser degree by the decrease in dynamic pressure. Very little is known, so far, about the downwash of a wing-fuselage combination whereas some information concerning the induced cross wind was obtained by the new measurements (Jacobs). According to the Graz measurements the influence of the wing-fuselage arrangement on the downwash seems to be even larger than the effect of the wing plan form - larger, for instance, than the difference between rectangular and trapezoidal wing; however, the wake of the fuselage and of the wing-fuselage arrangement is certainly

also of significance for the stability contribution of the elevator unit. Another new-type interference effect which is of importance for the dynamics of the airplane is lift due to sideslip and pitching moment due to sideslip. A few force measurements concerning this effect exist; however, they must be supplemented by pressure-distribution measurements in order to obtain more insight into the physical connections. Therefore the following measurements are suggested:

1. Measurements, supplementing the Graz measurements, on the arrangements wing + tail unit and fuselage + tail unit with various high positions of the tail unit.

2. Probe surface measurements for determination of the downwash on arrangements wing + fuselage and wing + nacelle (various high-positions of the probe surface).

3. Boundary-layer and wake measurements on wing-fuselage arrangements, especially on the rear part of the fuselage.

4. Cross-wind measurements with probe surface on wing-fuselage combinations.

5. Force- and pressure-distribution measurements regarding lift due to sideslip and pitching moment due to sideslip.

D. Measurements on Wing-Fuselage—Tail-Unit Measurements With Sweptback Wings

Because of the importance of the sweptback wing for high-speed airplanes, the aerodynamic coefficients of wing-fuselage and wing-fuselage—tail-unit arrangements with sweptback wings are of special significance. The displacement of the neutral point due to fuselage effect in case of sweptback wings has been pointed out. (See section III, 3.) Nothing is known regarding the downwash of sweptback wings alone, let alone of sweptback wing-fuselage arrangements. About the effectiveness of the rudder unit in case of wing-fuselage arrangements with sweptback wings, too little is known as yet. Thus the following tests are suggested:

1. Systematic downwash measurements with probe surface on sweptback wings alone. Such measurements for the wings indicated in figure 6 have already been started at the AITHB (Trienes).

2. Three-component measurements on wing + fuselage and wing + fuselage + tail-unit arrangements with sweptback wings. The measurements constitute an extension of the measurements by Möller (UM 2134) discussed in section III, 3. An aerodynamic-center program

according to figure 20 for wing-fuselage arrangements and wing-fuselage—tail-unit arrangements has been started. All arrangements used are mid-wing monoplanes; however, with the Graz measurements mentioned before taken into consideration it appears necessary to expand this aerodynamic-center program so as to include low-wing and shoulder-wing aircraft. Different from the Braunschweig interference measurements made so far, a fuselage with the location of maximum thickness at 30 percent was used in this aerodynamic-center program.

3. It seems to be necessary to carry out for a few arrangements of the aerodynamic-center program just mentioned, six-component measurements as well. In the existing six-component measurements on wing-fuselage arrangements with sweepback (FB 1318/4/5) the rearward position of the wing, measured as the distance from nose to $l_i/4$, had been kept constant; in the present new program the rearward position of the wing, measured up to the geometric neutral point of the wing, is kept constant and the tail lever arm also is measured from here which appears more sensible. Also, six-component measurements on wing + fuselage + tail unit with sweptback wings do not yet exist; however, in setting up the program for six-component measurements on wing + fuselage + tail unit with sweptback wing, the extent of the program has to be limited very strictly.

4. A similar test program on wing-fuselage combinations with sweptback wings for high-speed measurements has been set up by Mr. Puffert; it is to be carried out in the LFA-A9-tunnel, and has already been approved by the wind-tunnel committee.

5. For further clarification of the displacement of the neutral point due to fuselage effect in case of sweptback wings which are described above, it appears necessary to perform for one arrangement pressure-distribution measurements as well - and, for instance, for the arrangement fuselage I with wing $z = 1$, $\varphi = 45^\circ$, $e^*/a = 0.4$ (midwing monoplane according to figure 6). Above all, such pressure-distribution measurements are useful for providing a foundation for theoretical calculations regarding this problem which are now being made.

Translated by Mary L. Mahler
National Advisory Committee
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COMPILATION OF INTERFERENCE SYSTEMATICS AT THE AERODYNAMIC INSTITUTE OF THE TECHNICAL ACADEMY BRAUNSCHWEIG

(Force and Pressure-Distribution Measurements)

Status: January 1945

Force measurements: Three- and six-component measurements for

$$\alpha = -4^\circ \text{ to } +12^\circ$$

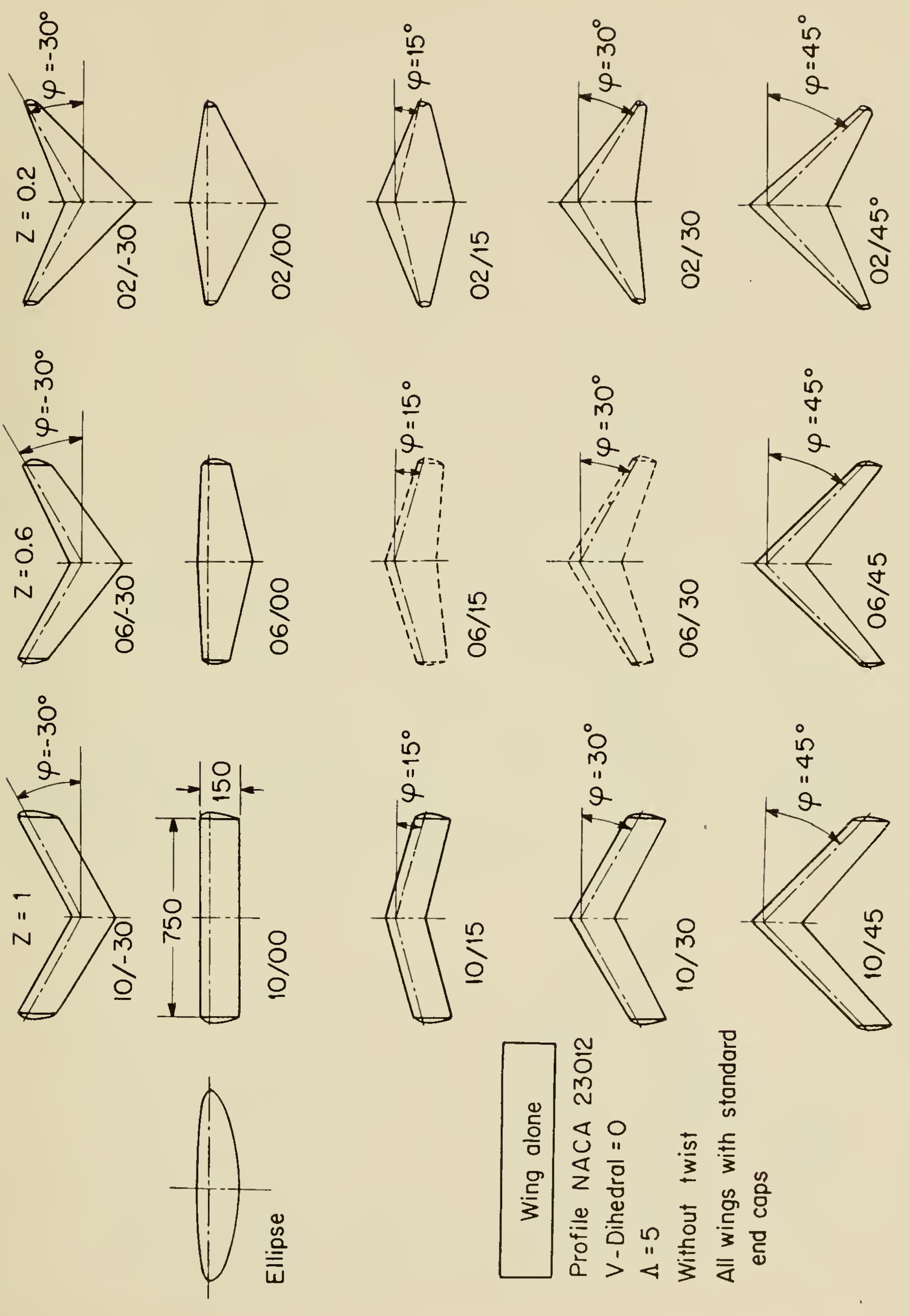
$$\beta = -30^\circ \text{ to } +30^\circ$$

Pressure-distribution measurements: for the same sectors

$$v = 40 \text{ m/sec}; \ \frac{vl}{\nu} = 4.2 \times 10^5$$

Author: E. Möller

Reviewer: Schlichting


Z = 0.2
φ = -30°
02/-30
02/00
φ = 15°
02/15
φ = 30°
02/30
φ = 45°
02/45°
Z = 0.6
φ = -30°
06/-30
06/00
φ = 15°
06/15
φ = 30°
06/30
φ = 45°
06/45
Z = 1
φ = -30°
10/-30
750
150
10/00
φ = 15°
10/15
φ = 30°
10/30
φ = 45°
10/45
Ellipse
Wing alone
Profile NACA 23012
V-Dihedral = 0
Λ = 5
Without twist
All wings with standard end caps

Pertaining to page 13

COMPILATION OF INTERFERENCE SYSTEMATICS

WING ALONE

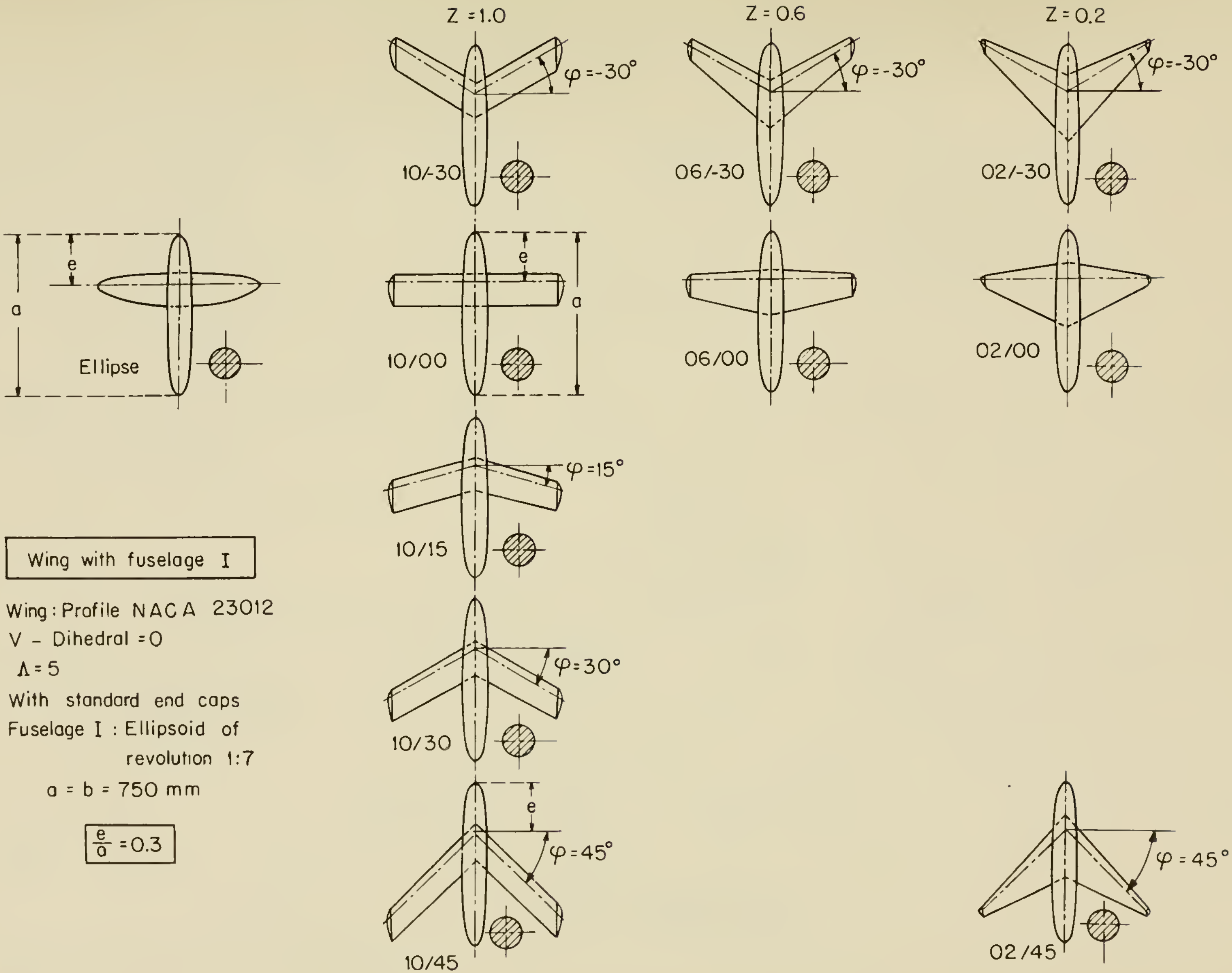
Wing	Sweepback shape φ^{o}	Dihedral ν^{o}	Taper $z = l_a/l_i$	Measurement		Interoffice report		Published	
				Force	Pressure distribution	Force measurement	Pressure-distribution measurement	Force measurement	Pressure-distribution measurement
Ellipse	---	0;3;6	---	⊗		40/7		FB 1318/1	
10/-30	-30	0		⊗	○	44/19		UM 2103	
10/00	0	0;3;6		⊗	(ν = 0)⊗	40/9	43/13-13a (ν = 0)		Yearbook Aviation Research 1943, page 1
10/15	15	0	1.0	⊗	⊗	44/21	43/2	FB 1629	UM 2083
10/30	30	0		⊗	⊗	41/8	44/28		
10/45	45	0		⊗	⊗		44/12		UM 2110
06/-30	-30			⊗		44/19		UM 2103	
06/00	0			⊘		41/5		FB 1318/3	
06/15	15	0	0.6	Not measured		-------------		---------	
06/30	30					-------------		---------	
06/45	45			⊘		44/4 (44/21)		UM 2069	
02/-30	-30			⊗		44/19		UM 2103	
02/00	0			⊗		41/5		FB 1318/3	
02/15	15	0	0.2	⊗					
02/30	30			⊗		44/4		UM 2069	
02/45	45			⊗		(44/21)			

○ Measurement being prepared

⊗ Measurement concluded

Wing profile NACA 23012

$b = 0.750\text{m}$, $\Lambda = 5$ } without end caps


Z = 1.0
Z = 0.6
Z = 0.2
φ = -30°
φ = -30°
φ = -30°
10/-30
06/-30
02/-30
e
a
Ellipse
10/00
06/00
02/00
φ = 15°
10/15
φ = 30°
10/30
φ = 45°
10/45
φ = 45°
02/45
Wing with fuselage I
Wing: Profile NACA 23012
V - Dihedral = 0
Λ = 5
With standard end caps
Fuselage I : Ellipsoid of revolution 1:7
a = b = 750 mm
e/a = 0.3

Pertaining to page 15

COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE I (ELLIPSOID OF REVOLUTION 1:7)

Wing	Arrangement	Rearward position of wing e/a	Measurement: Force	Measurement: Pressure distribution	Interoffice report: Force measurement	Interoffice report: Pressure-distribution measurement	Published: Force measurement	Published: Pressure-distribution measurement
Ellipse	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	0.3	⊗		40/7		FB 1318/1 Yearbook Aviation Research 1942 I 336	
10/00	"Low-wing monoplane" Low-wing monoplane Semilow-wing monoplane Midwing monoplane Semishoulder-wing monoplane Shoulder-wing monoplane High-wing monoplane Shoulder-wing monoplane	0.3 0.3;0.7 (β = 0) 0.3 0.3; 0.5; 0.7 (β = 0) 0.3 0.3 0.3 0.2;0.4; 0.5;0.7	⊗	⊗ (only wing) ⊗ (β = 0) ⊗ (β = 0) ⊗ (β = 0) ⊗ (β = 0)	40/9;44/25 41/4;44/25 43/12	42/14,14a 42/17;44/22 43/9;44/22 44/20;44/22 42/14,14a 44/6;44/22	FB 1318/2 Yearbook Aviation Research 1942 I 336 FB 1318/3	Yearbook Aviation Research 1943+) FB 1710/1 FB 1710/2 FB 1710/4 FB 1710/3 Yearbook Aviation Research 1943+)
10/15	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	⊗		43/17		FB 1318/4	
10/30	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	⊗		43/17		FB 1318/4	
10/45	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	⊗		43/17		FB 1318/4	
06/00	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	0.3	⊗		41/5		FB 1318/3 Yearbook Aviation Research 1942 I 336	
02/00	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	0.3	⊗		41/5		FB 1318/3 Yearbook Aviation Research 1942 I 336	
02/45	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	⊗		44/5		FB 1318/5	

○ Measurement being prepared

⊗ Measurement concluded

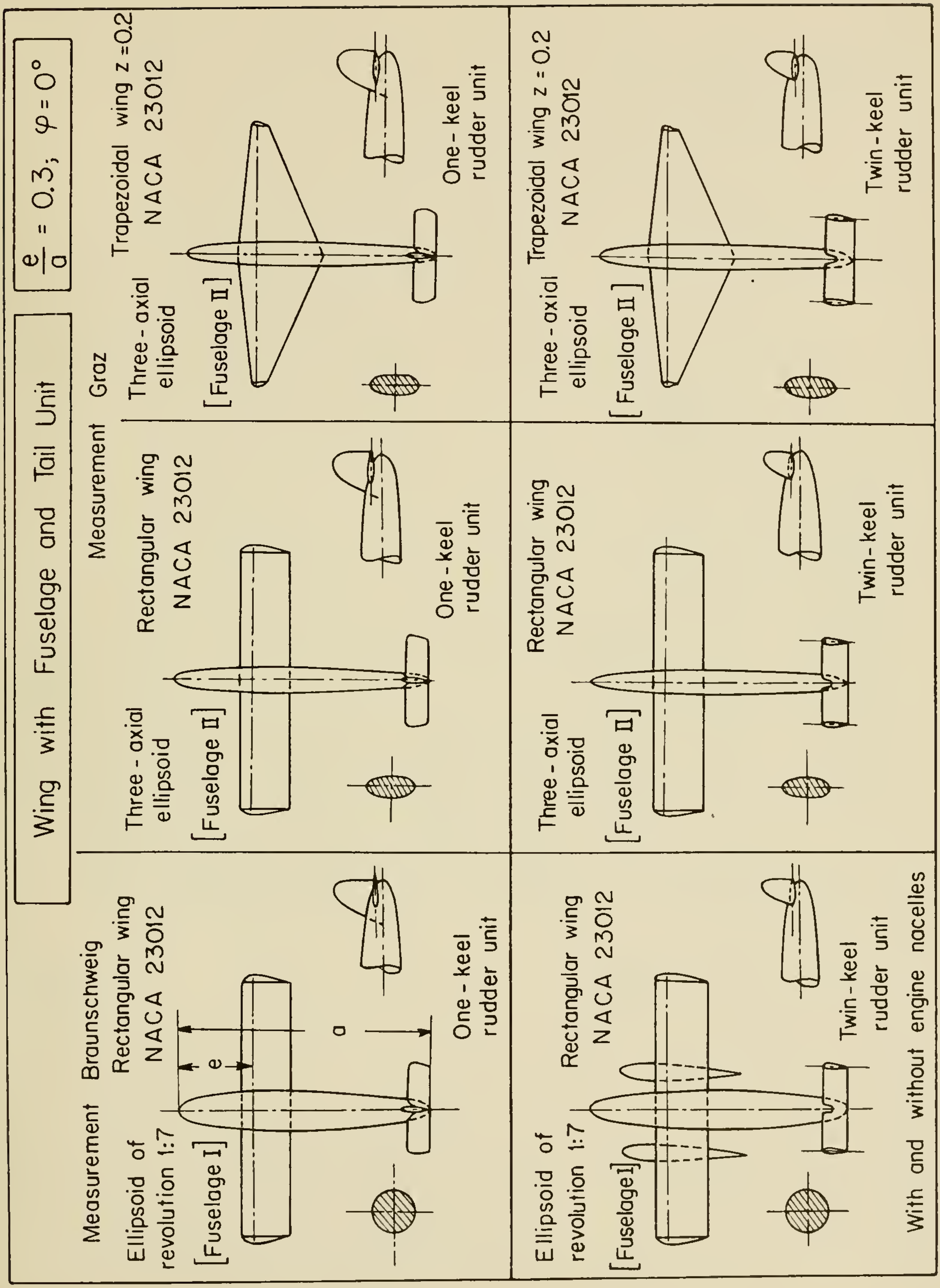
Wing profile NACA 23012

b = 0.750m, Λ = 5 } without end caps

Fuselage I: ellipsoid of revolution 1:7

a = 0.750m

+)Preprint: Technical Reports, vol. 11, issue 5, 1944


Wing with Fuselage and Tail Unit
$\frac{e}{a} = 0.3;\ \varphi = 0°$
Measurement Braunschweig
Ellipsoid of revolution 1:7
[Fuselage I]
Rectangular wing
NACA 23012
e
a
One-keel rudder unit
Measurement Graz
Three-axial ellipsoid
[Fuselage II]
Rectangular wing
NACA 23012
One-keel rudder unit
Three-axial ellipsoid
[Fuselage II]
Trapezoidal wing z = 0.2
NACA 23012
One-keel rudder unit
Ellipsoid of revolution 1:7
[Fuselage I]
Rectangular wing
NACA 23012
Twin-keel rudder unit
With and without engine nacelles
Three-axial ellipsoid
[Fuselage II]
Rectangular wing
NACA 23012
Twin-keel rudder unit
Three-axial ellipsoid
[Fuselage II]
Trapezoidal wing z = 0.2
NACA 23012
Twin-keel rudder unit

Pertaining to page 17

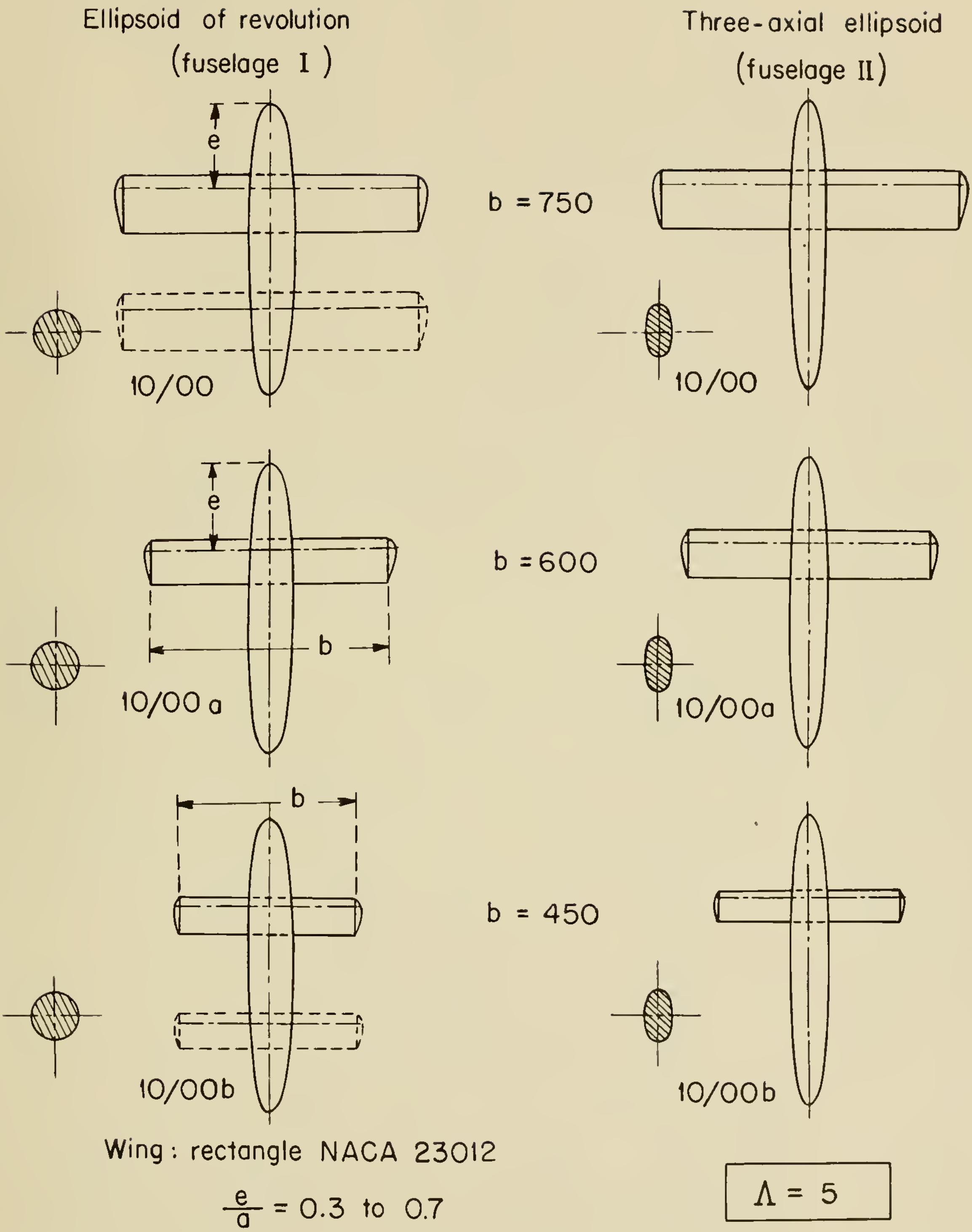
COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE AND TAIL UNIT

Wing	Fuselage	Arrangement	Rudder unit	Force measurement	Interoffice report	Published
Rectangle 10/00	I	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	One-keel	⊗	41/3 41/3a	Yearbook Aviation Research 1943+)
Rectangle 10/00	I	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	Twin-keel	⊗	41/3 41/3a	Yearbook Aviation Research 1943
Rectangle 10/00	I With two nacelles	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	Twin-keel	⊗	44/14	FB 1921/2
Rectangle 10/00	II	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	One-keel	⊗	Report Technical Academy Graz	
Rectangle 10/00	II	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	Twin-keel	⊗	Report Technical Academy Graz	
Trapezoid $z = 0.2$	II	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	One-keel	⊗	Report Technical Academy Graz	
Trapezoid $z = 0.2$	II	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	Twin-keel	⊗	Report Technical Academy Graz	

○ Measurement being prepared ⊗ Measurement concluded

+)Preprint: Technical Reports, vol. 11, issue 6, June 1944


Ellipsoid of revolution
(fuselage I)
Three-axial ellipsoid
(fuselage II)
e
b = 750
10/00
10/00
e
b = 600
b
10/00 a
10/00a
b
b = 450
10/00b
10/00b
Wing: rectangle NACA 23012
e/a = 0.3 to 0.7
Λ = 5

Pertaining to page 19

COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE

Wing	Fuselage	Arrangement	Rearward position of wing e/a	Force measurement	Interoffice report	Published
10/00 b = 0.750m	I	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3;0.7 0.3;0.5;0.7 0.2;0.3;0.4 0.5;0.7	⊗ ⊗ ⊗	43/12;44/25 (β = 0)	
10/00a b = 0.600m	I	Midwing monoplane	0.3;0.5;0.7	⊗	43/12;44/25 (β = 0)	
10/00b b = 0.450	I	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3;0.7 0.3;0.5;0.7 0.3;0.7	⊗ ⊗ ⊗	43/12;44/25 (β = 0)	Will be published shortly as FB 2023
10/00	II	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane High-wing monoplane	0.3 0.3;0.5;0.7 0.3	⊗ ⊗ ⊗ ⊗	43/12;41.4 44/25 (β = 0)	Also FB 1318/3
10/00a	II	Midwing monoplane	0.3;0.5;0.7	⊗	43/12;44/25 (β = 0)	
10/00b	II	Midwing monoplane	0.3;0.5;0.7	⊗	43/12;44/25 (β = 0)	

○ Measurement being prepared

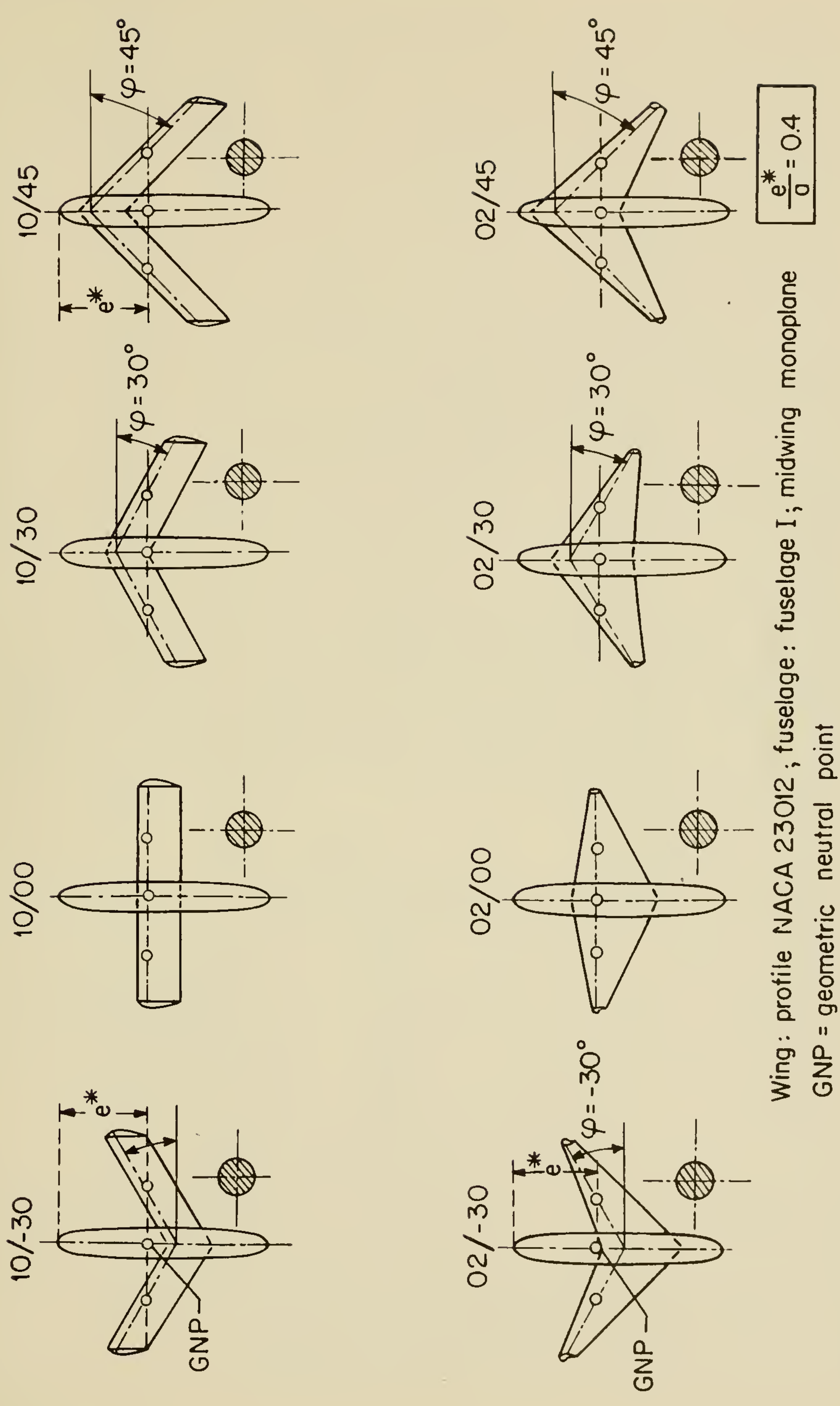
⊗ Measurement concluded

Fuselage I: ellipsoid of revolution 1:7

Fuselage II: three-axial ellipsoid $a_1/b_1 = 1.5$

$a = 0.750\text{m}$; $F_{st} = 0.0090\text{m}^2$; $\Lambda = 5$

Wing: profile NACA 23012


10/-30
10/00
10/30
10/45
02/-30
02/00
02/30
02/45
e*
φ = -30°
φ = 30°
φ = 45°
GNP
e*/a = 0.4
Wing: profile NACA 23012; fuselage: fuselage I; midwing monoplane
GNP = geometric neutral point

Pertaining to page 21

COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE (SWEPTBACK WING)

Wing	Fuselage	Arrangement	Rearward position of wing e^*/a	Tail unit	Force measurement	Interoffice report	Published
10/-30 10/00 10/30 10/45	I	Midwing monoplane	0.4	---	○ ○ ○ ○		
02/-30 02/00 02/30 02/45	I	Midwing monoplane	0.4	---	⊗ ⊗ ⊗ ⊗	44/29	UM 2134

○ Measurement being prepared

⊗ Measurement concluded

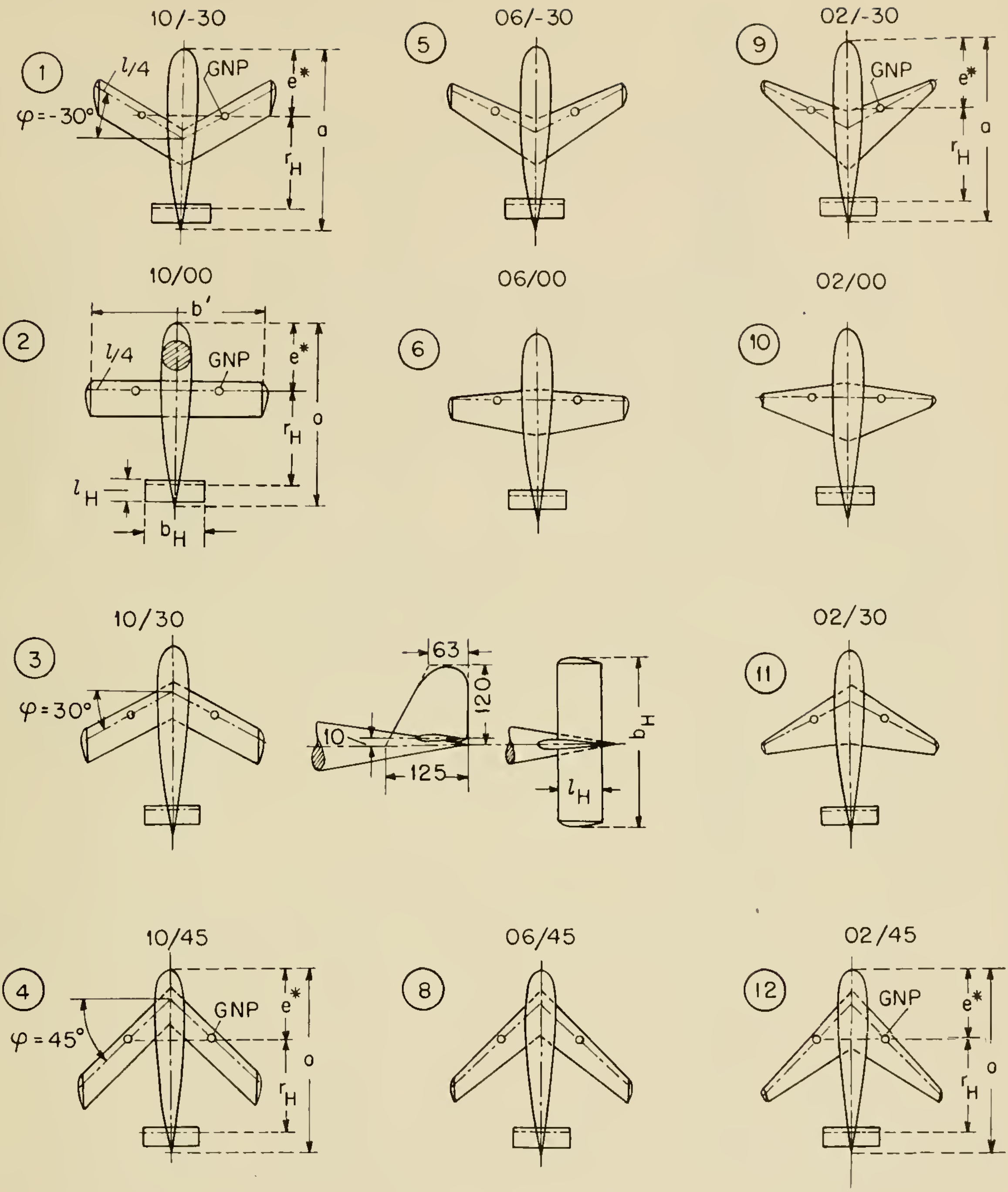
Wing: profile NACA 23012

$$\left.\begin{array}{l} b = 0.750\text{m} \\ \Lambda = 5 \end{array}\right\} \text{without end caps}$$

Fuselage I: ellipsoid of revolution 1:7

$$a = 0.750\text{m}$$

$$F_{st} = 0.0090\text{m}^2$$



Wing: profile NACA 23012
Fuselage: fus-III (NACA 0015)
Tail unit: tail unit I (one-keel)

$\frac{e^*}{a} = 0.4$

$\frac{r_H}{b'/2} = 1.04$

All arrangements are midwing monoplanes
GNP = geometric neutral point

Pertaining to page 23

COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE AND TAIL UNIT

Wing	Fuselage	Arrangement	Rearward position of wing e^*/a	Tail unit	Force measurement	Interoffice report	Published
10/-30 10/00 10/30 10/45	III	Midwing monoplane	0.4	Without and with One- and Twin-keel	○ (β = 0) ○ (β = 0) ○ (β = 0) ○ (β = 0)		
06/-30 06/00 06/45	III	Midwing monoplane	0.4	Without and with One- and Twin-keel	○ (β = 0) ○ (β = 0) ○ (β = 0)		
02/-30 02/00 02/30 02/45	III	Midwing monoplane	0.4	Without and with One- and Twin-keel	○ (β = 0) ○ (β = 0) ○ (β = 0) ○ (β = 0)		

○ Measurement being prepared

⊗ Measurement concluded

Wing: profile NACA 23012

$\left.\begin{array}{l} b = 0.750\text{m} \\ \Lambda = 5 \end{array}\right\}$ without end caps

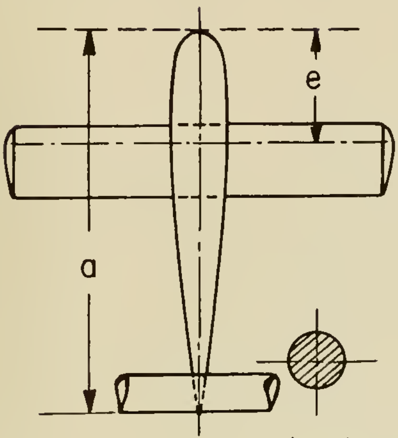
Fuselage III: NACA 0015 rotationally symmetrical fuselage

Fuselage IV: elliptic fuselage $a_1/b_1 = 1.5$

$a = 0.750\text{m}$

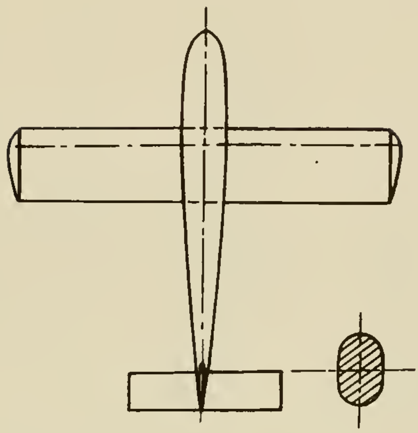
$F_{st} = 0.0090\text{m}^2$

Fuselage III (NACA 0015)



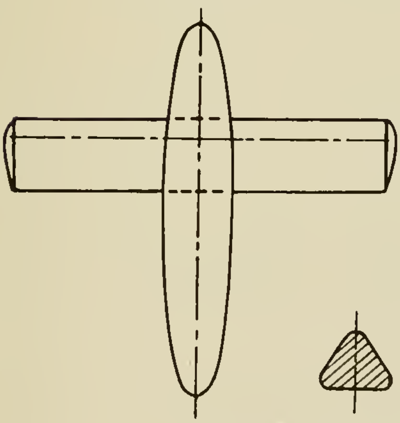
Circular cross section

Fuselage IV



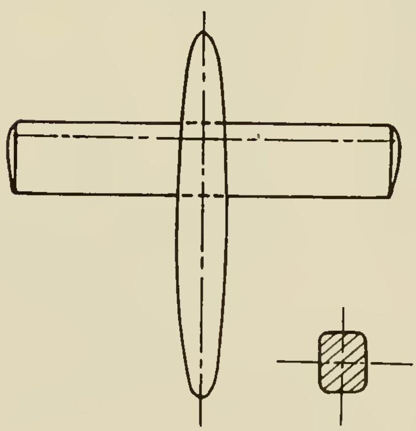
Elliptic cross section

Fuselage V



Pear-shaped cross section

Fuselage VI



Rectangular cross section

Pertaining to page 25

COMPILATION OF INTERFERENCE SYSTEMATICS

WING WITH FUSELAGE AND TAIL UNIT (VARIOUS FUSELAGE SHAPES)

Wing	Fuselage	Arrangement	Rearward position of wing e/a	Tail unit	Force measurement	Interoffice report	Published
10/00	III	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	Without and with One- and Twin-keel	○ ○ ○		
10/00	IV	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	Without and with One- and Twin-keel	○ ○ ○		
10/00	V	Low-wing monoplane Midwing monoplane Shoulder-wing monoplane	0.3	Without	○ ○ ○		
10/00	VI	Low-wing monoplane Shoulder-wing monoplane	0.3	Without	○ ○		

○ Measurement being prepared

⊗ Measurement concluded

Wing: profile NACA 23012

$$\left.\begin{aligned} b &= 0.750\text{m} \\ \Lambda &= 5 \end{aligned}\right\} \text{without end caps}$$

Fuselage V: pear-shaped cross section (according to Riegals, Yearbook 1942, Aviation Research, page 1, 263)

Fuselage VI: rectangular cross section (according to Maruhn, Yearbook 1942, Aviation Research, page 1, 366)

$a = 0.750\text{m}$

$F_{st} = 0.0090\text{m}^2$

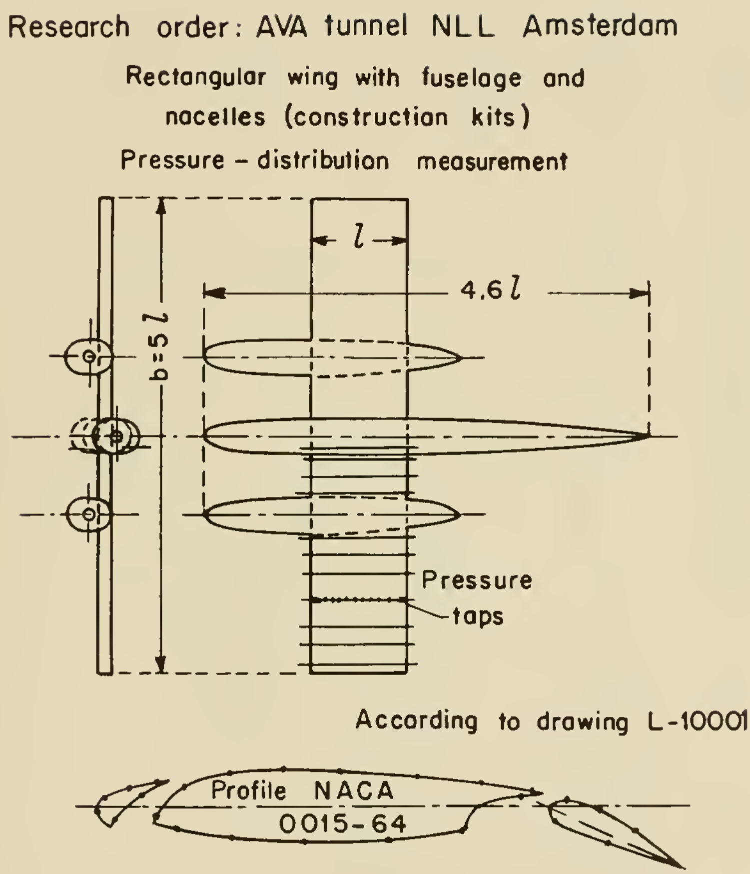


Figure 1.- AVA pressure-distribution measurements on combinations: wing + fuselage + nacelle. Dia. 1661.

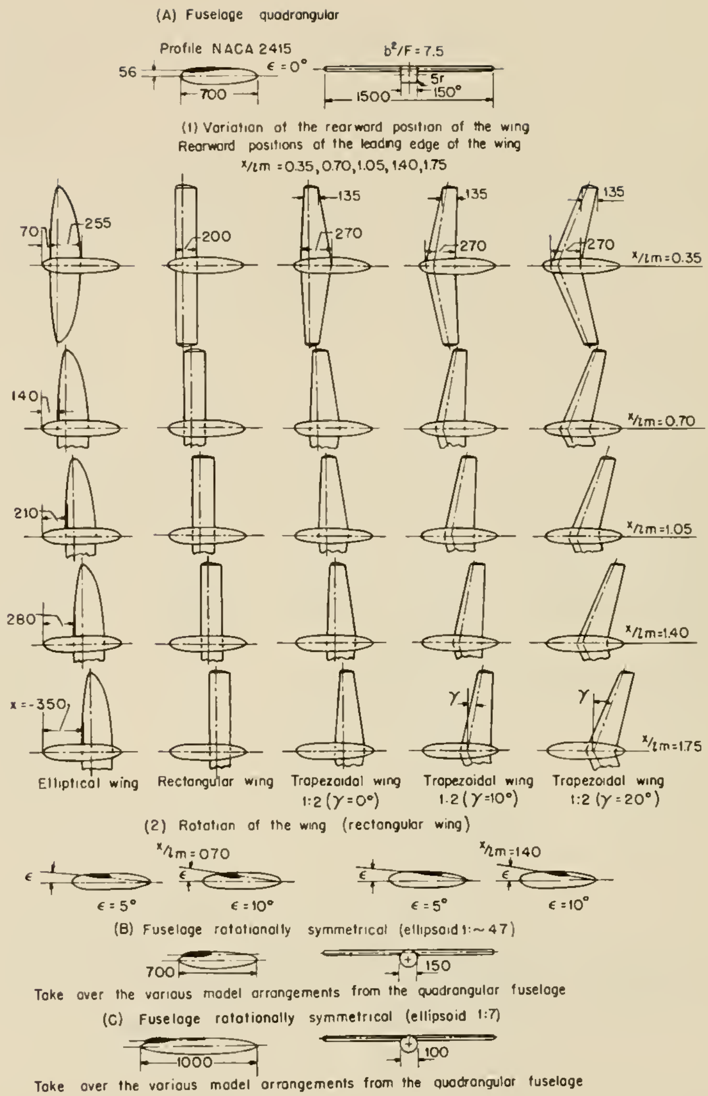


Figure 2.- LFA program; six-component measurements on wing-fuselage arrangements. Dia. 1659.

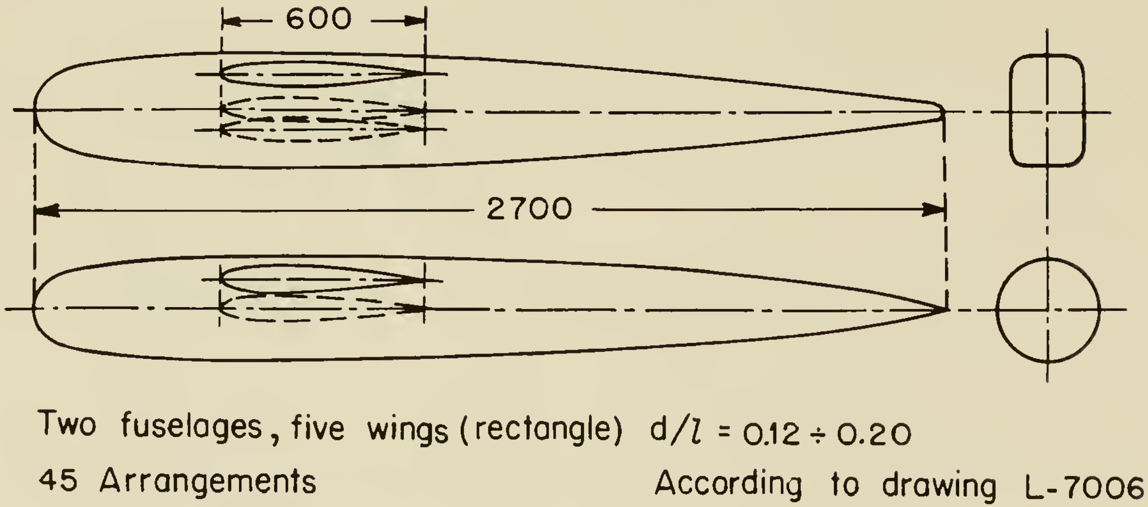
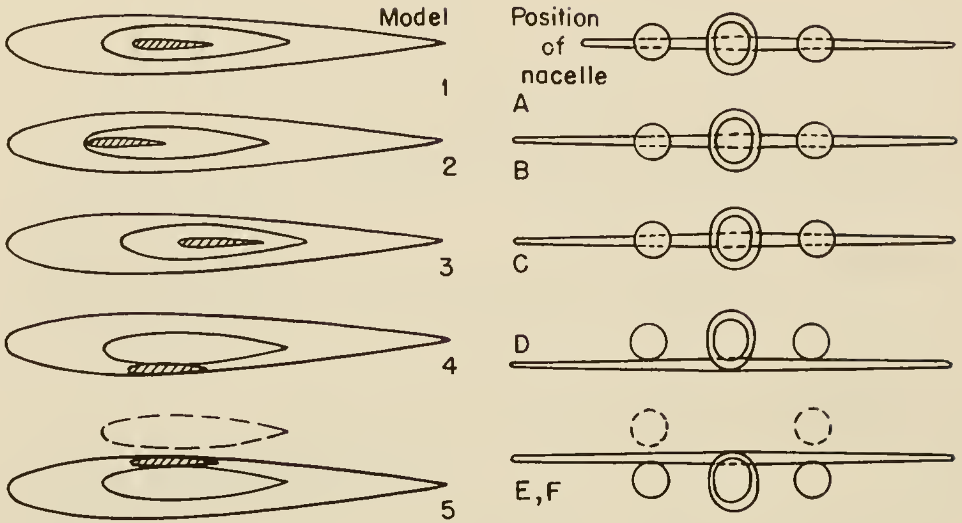


Figure 3.- AVA c_{wp} measurements on wing fuselage combinations.
Dia. 1662.



Nacelle: profile NACA 0019-1.1-40; wing: trapezoid z = 0.5
Inside: NACA 0012-0.825-40. Outside: NACA 0010-0.825-40.

LFA program No.30 tunnel A2

Messerschmitt order; drag of combination wing-fuselage nacelle at high speed

Figure 4.- LFA tunnel A2. High-speed measurements on combinations: wing + fuselage + nacelle. Dia. 1663.

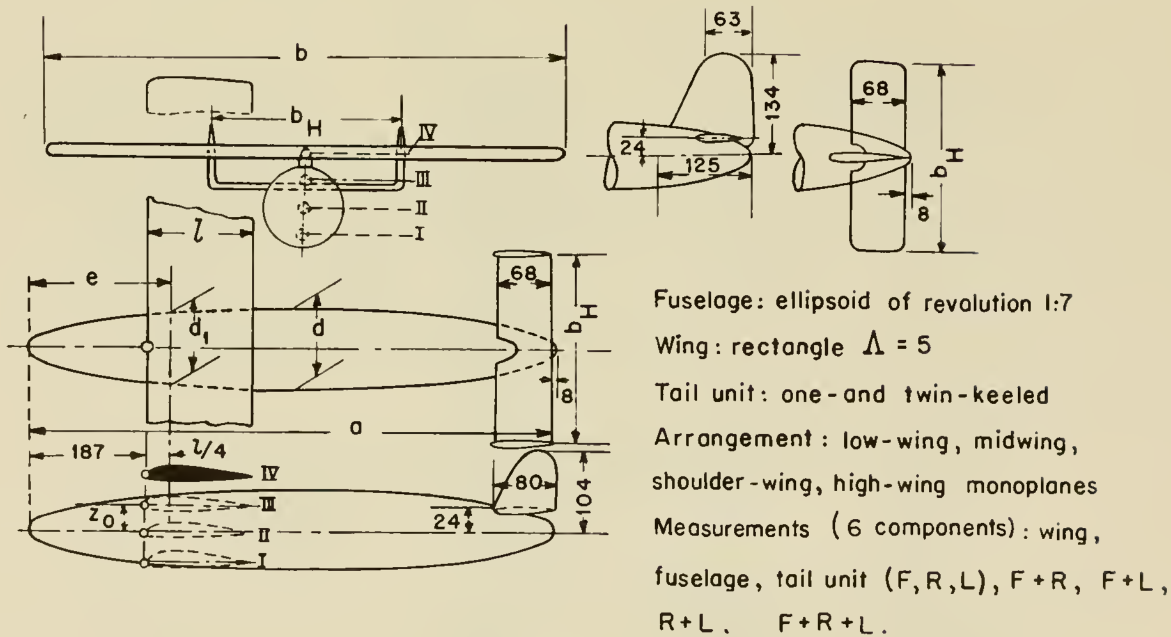


Figure 5.- AITHB; sectional complete model for six-component measurements. Dia. 1660.

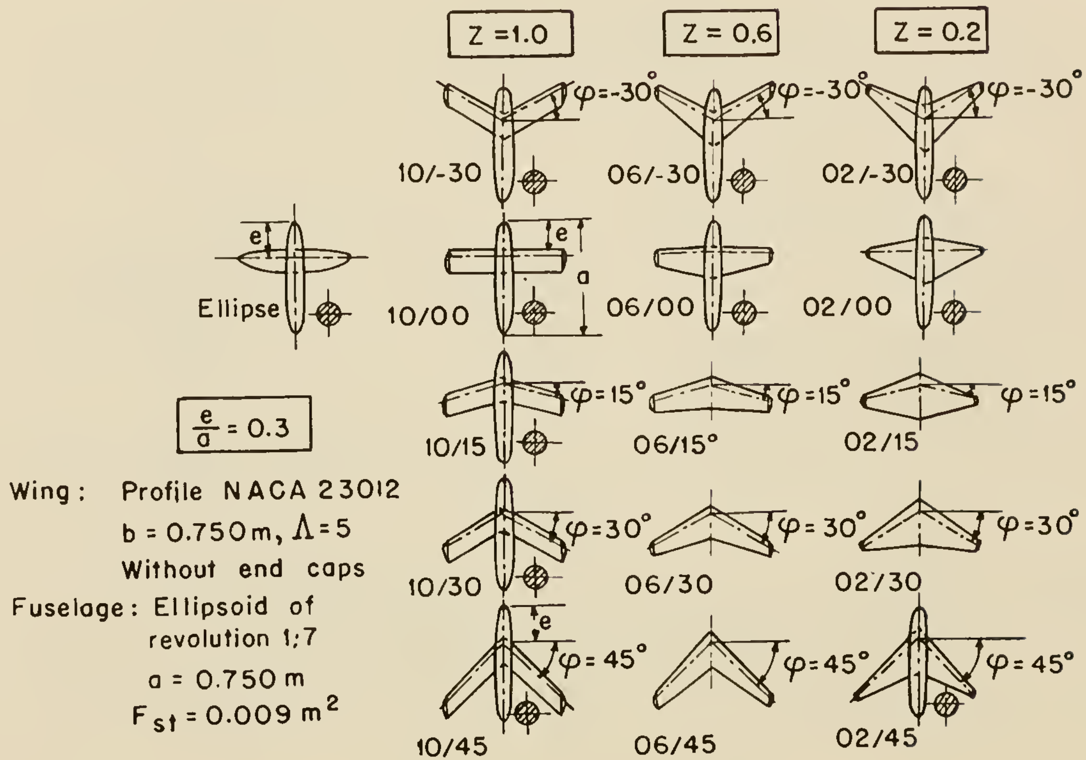


Figure 6.- Survey of the sweptback wings and of the wing-fuselage arrangements with sweptback wings of the AITHB.

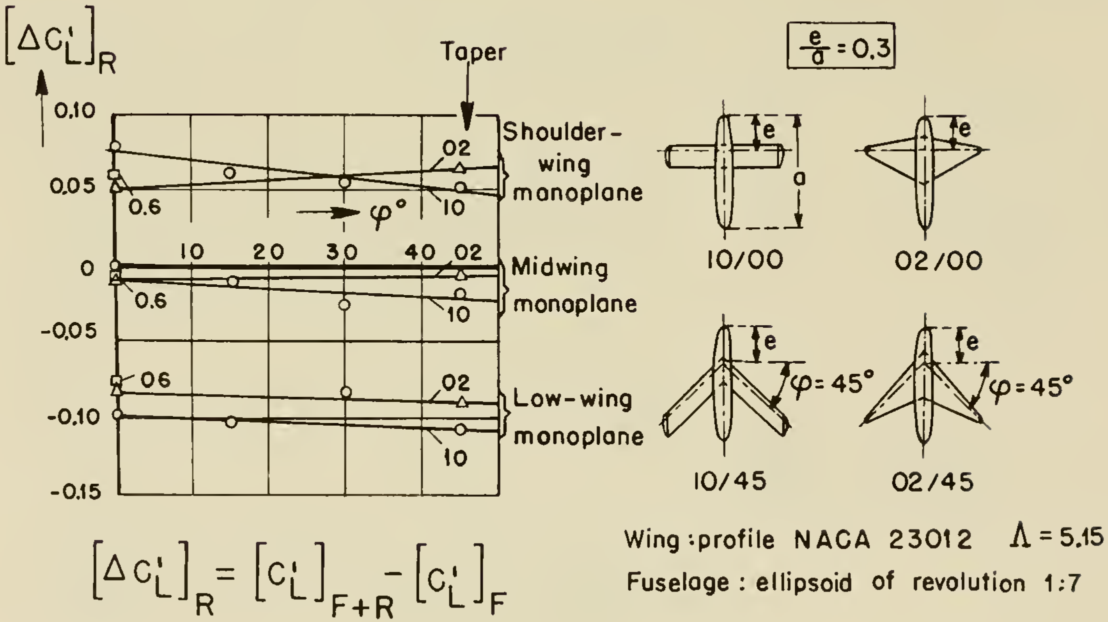


Figure 7.- The additional fuselage contribution to the rolling moment due to sideslip as a function of sweepback angle and wing taper.

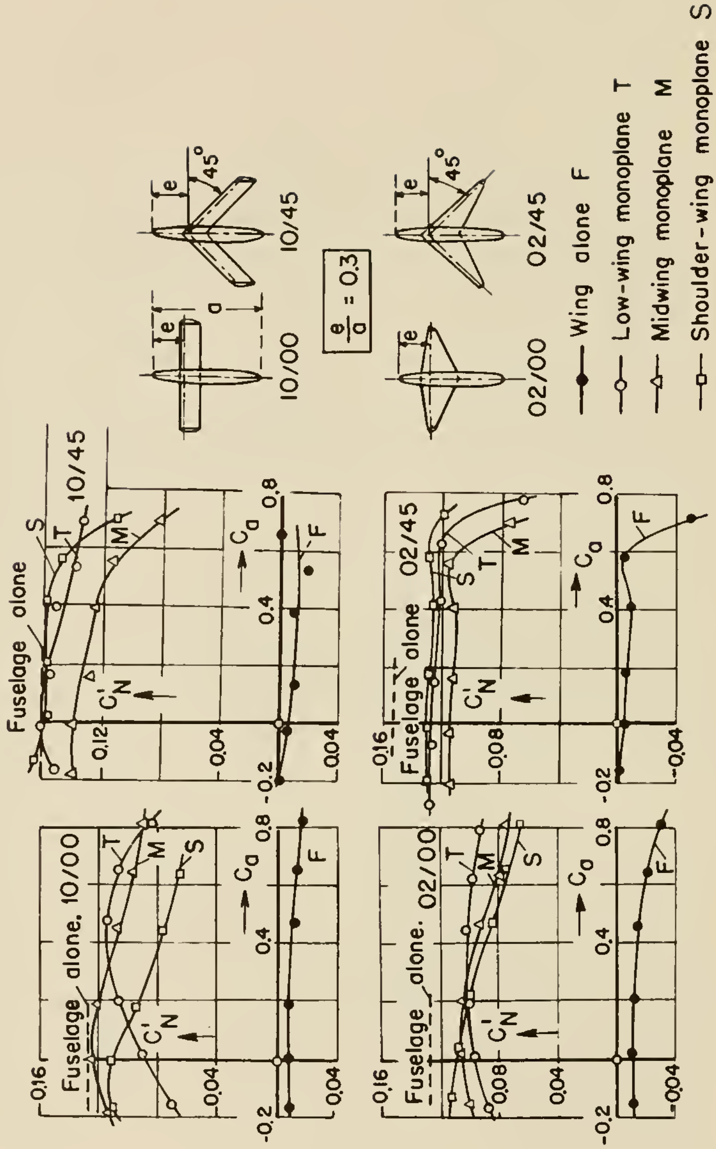


Figure 8.- Directional stability of arrow-type wing-fuselage arrangements.

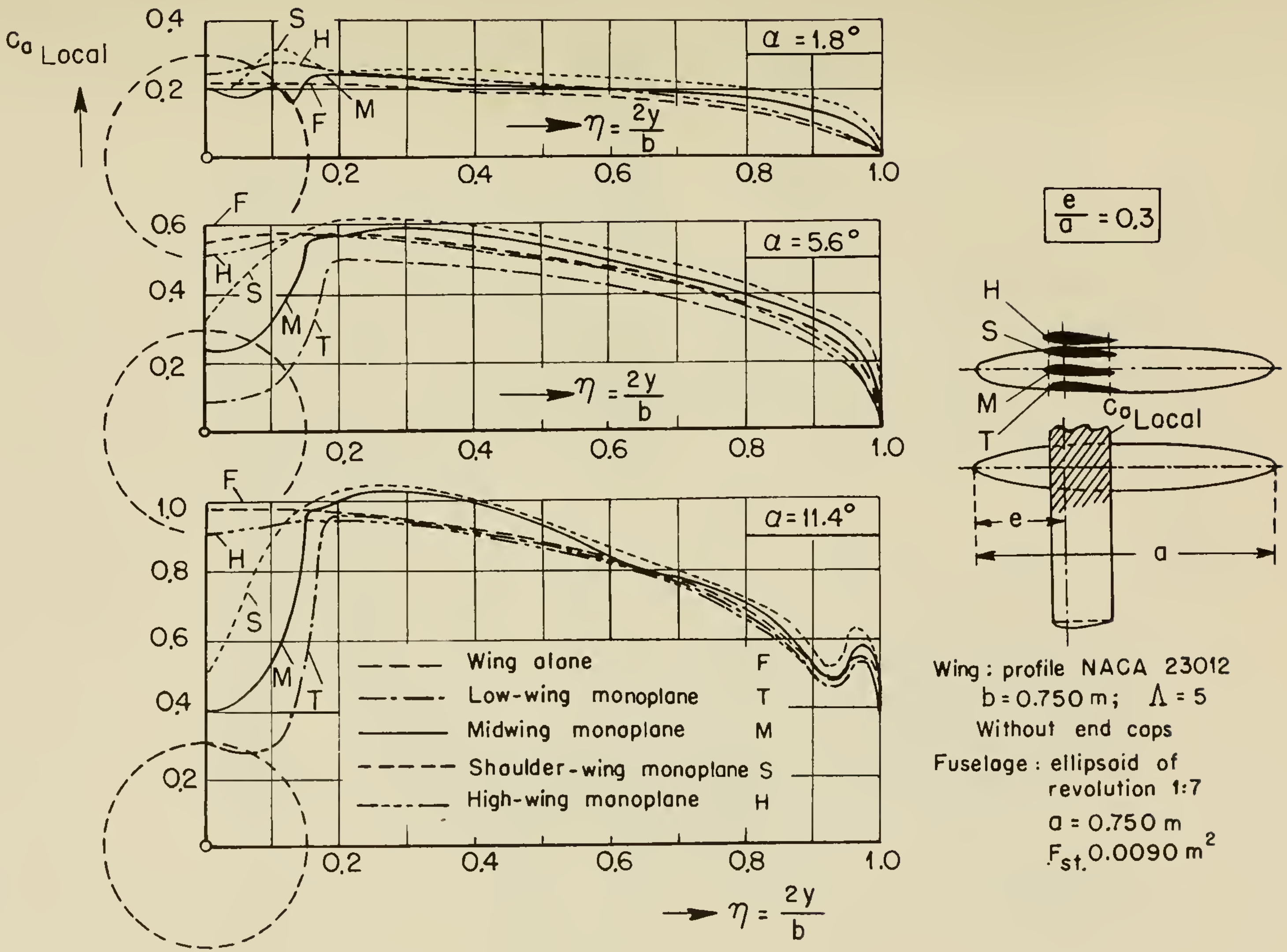


Figure 9.- Pressure-distribution measurements on wing-fuselage arrangements. Lift distribution along span.

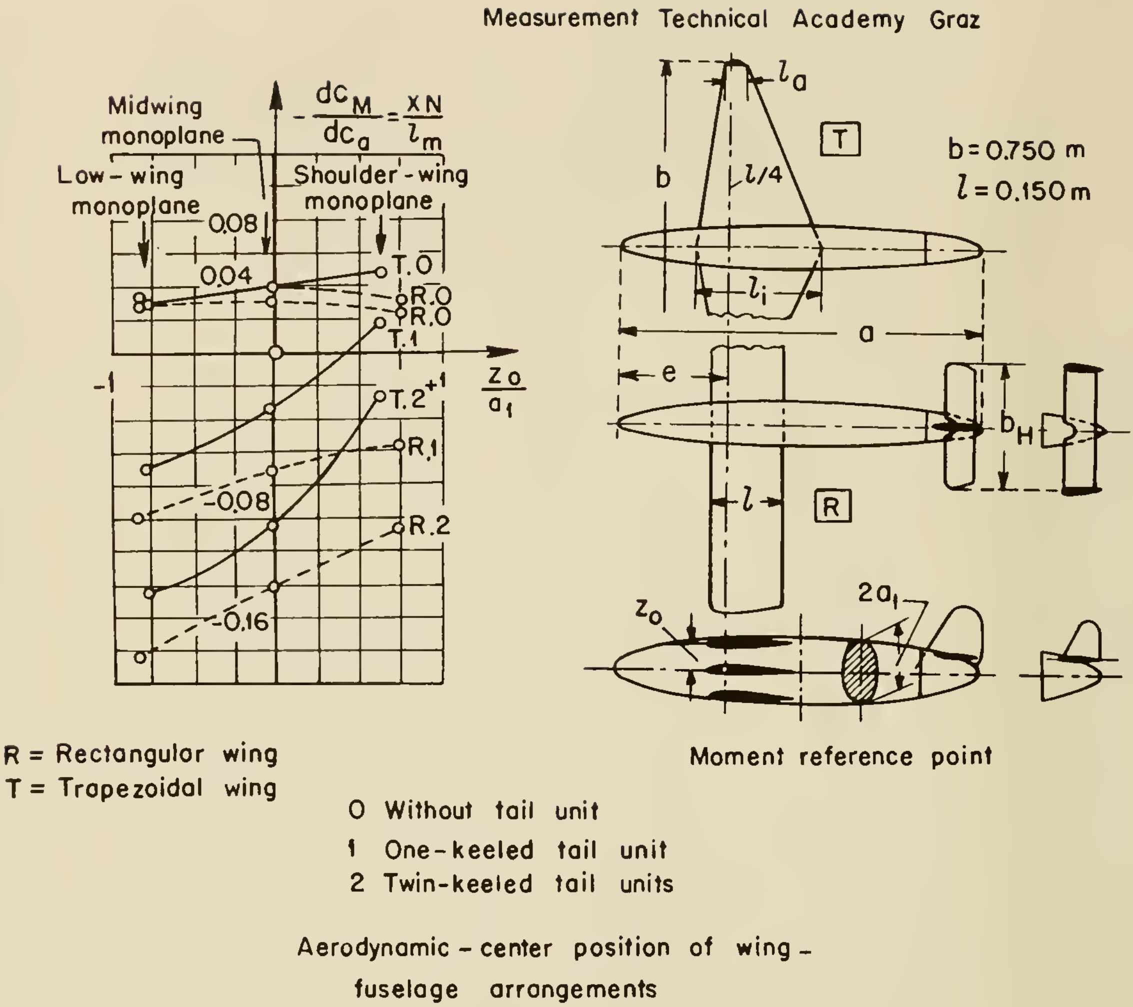


Figure 10.- Displacement of the neutral point for the arrangements wing + fuselage + tail unit (measurements Graz).

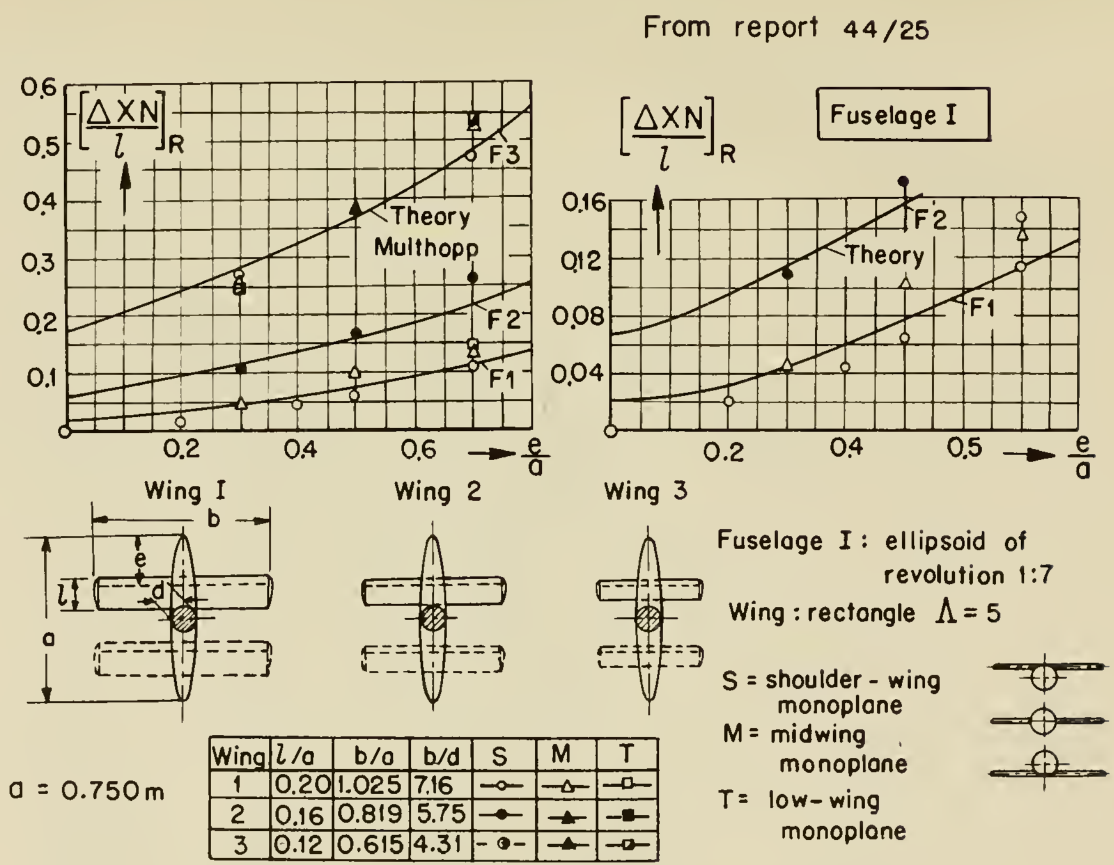


Figure 11.- Shifting of aerodynamic center due to fuselage effect.

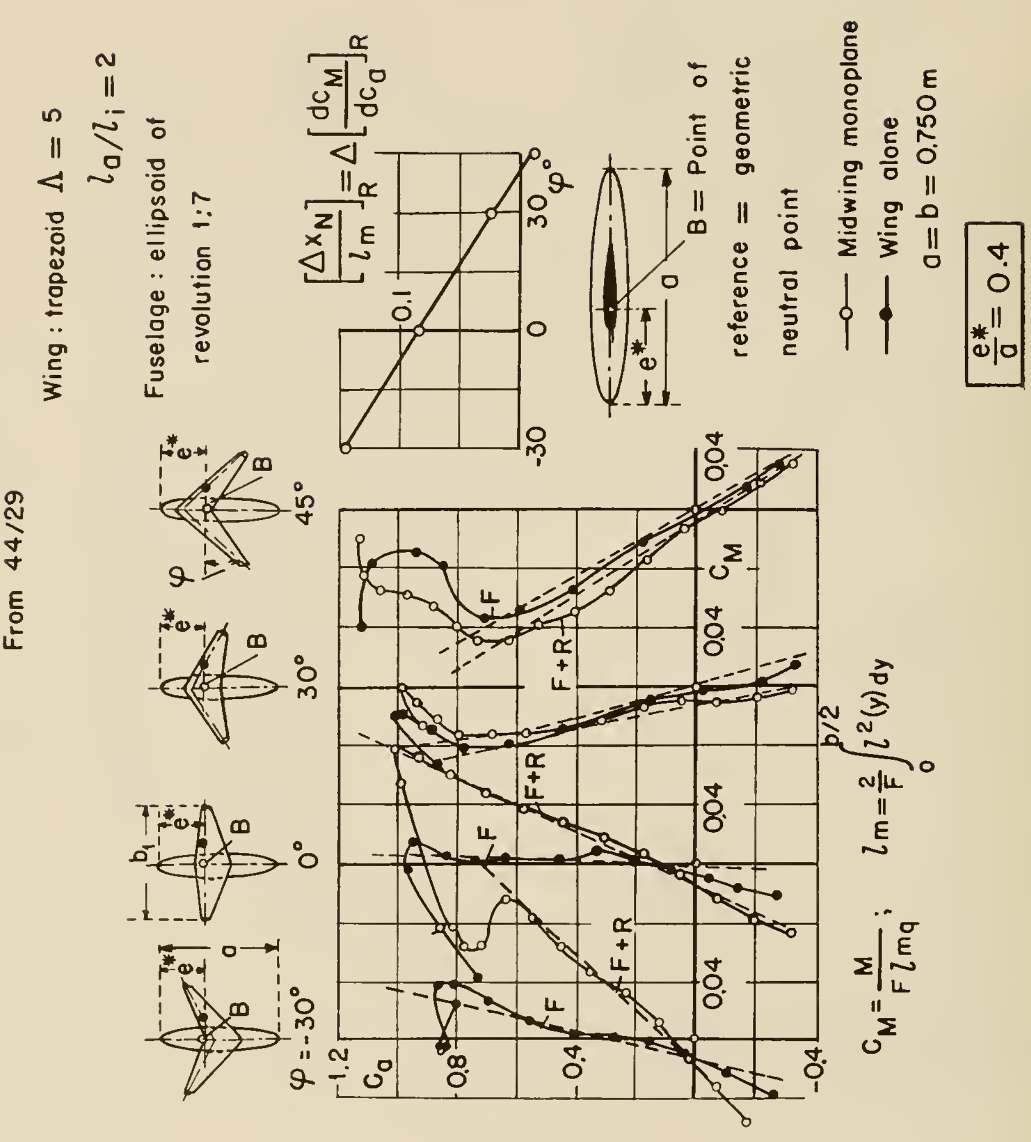


Figure 12.- Shifting of aerodynamic center due to fuselage effect in case of sweptback wings.

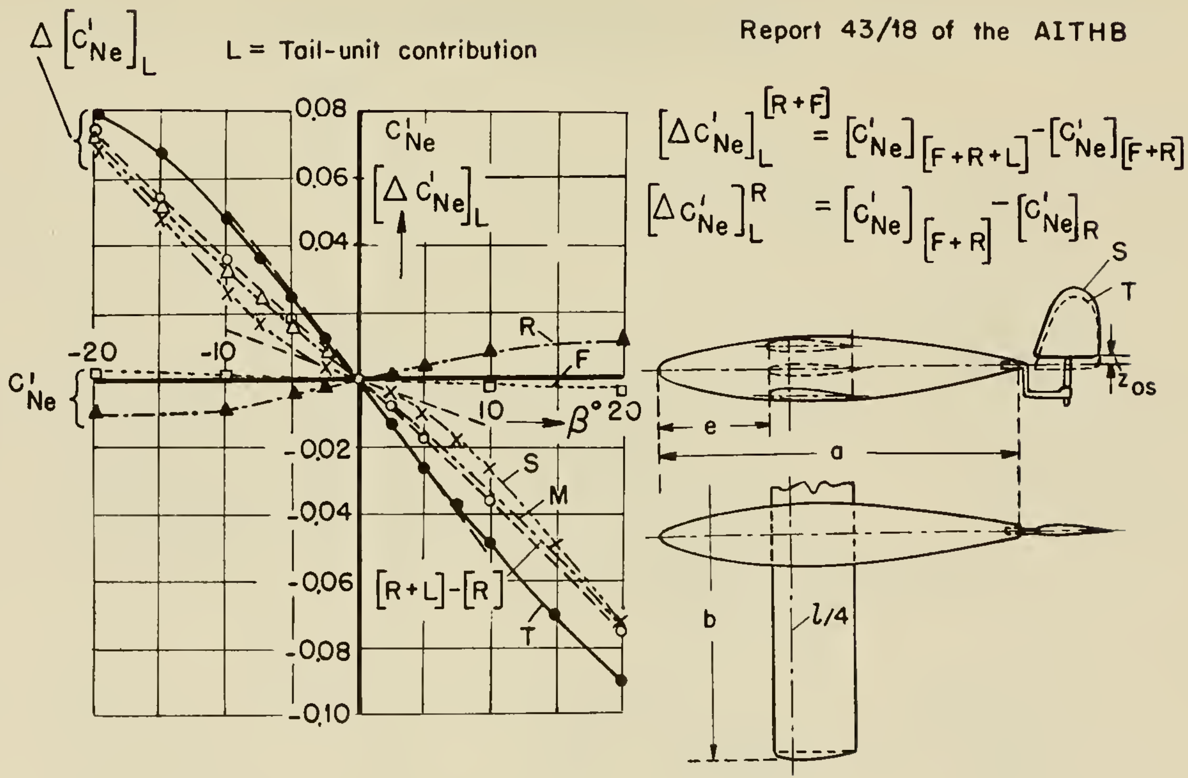


Figure 13.- Yawing moment due to sideslip of three complete models: low-wing, midwing and shoulder-wing monoplane.

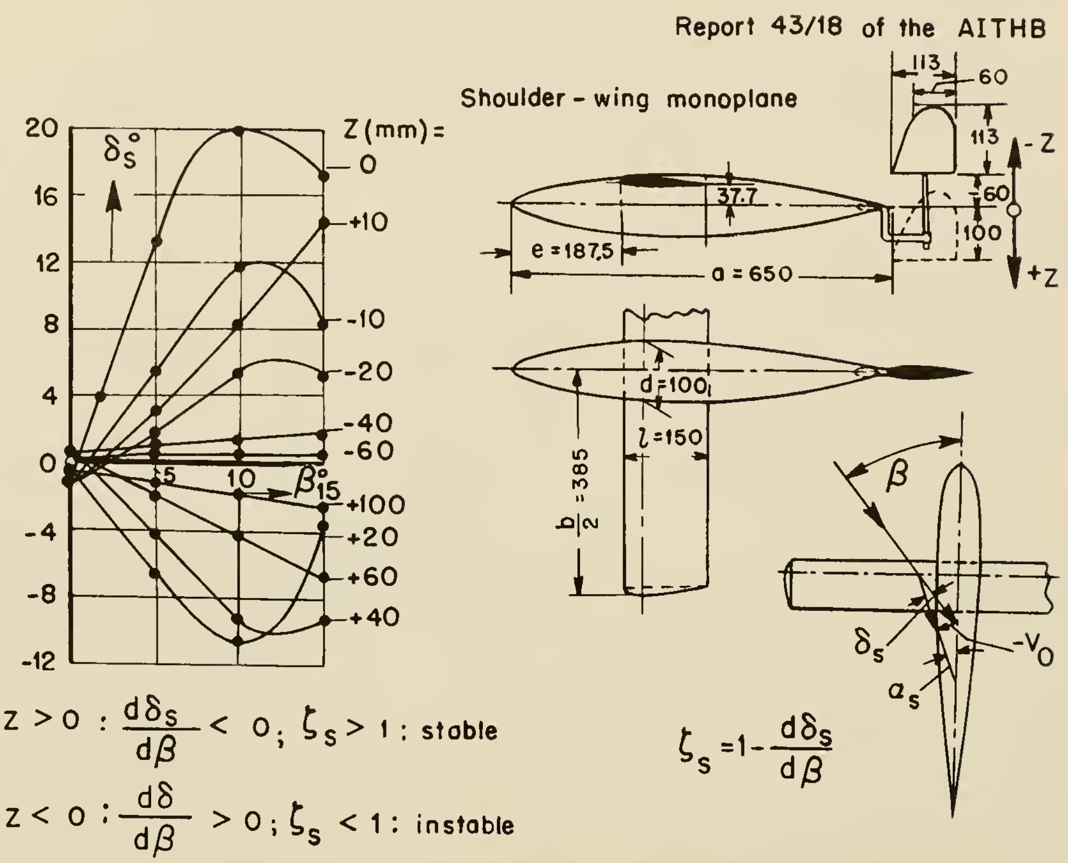


Figure 14.- Directional measurements concerning the induced cross wind on a low-wing and shoulder-wing monoplane model.

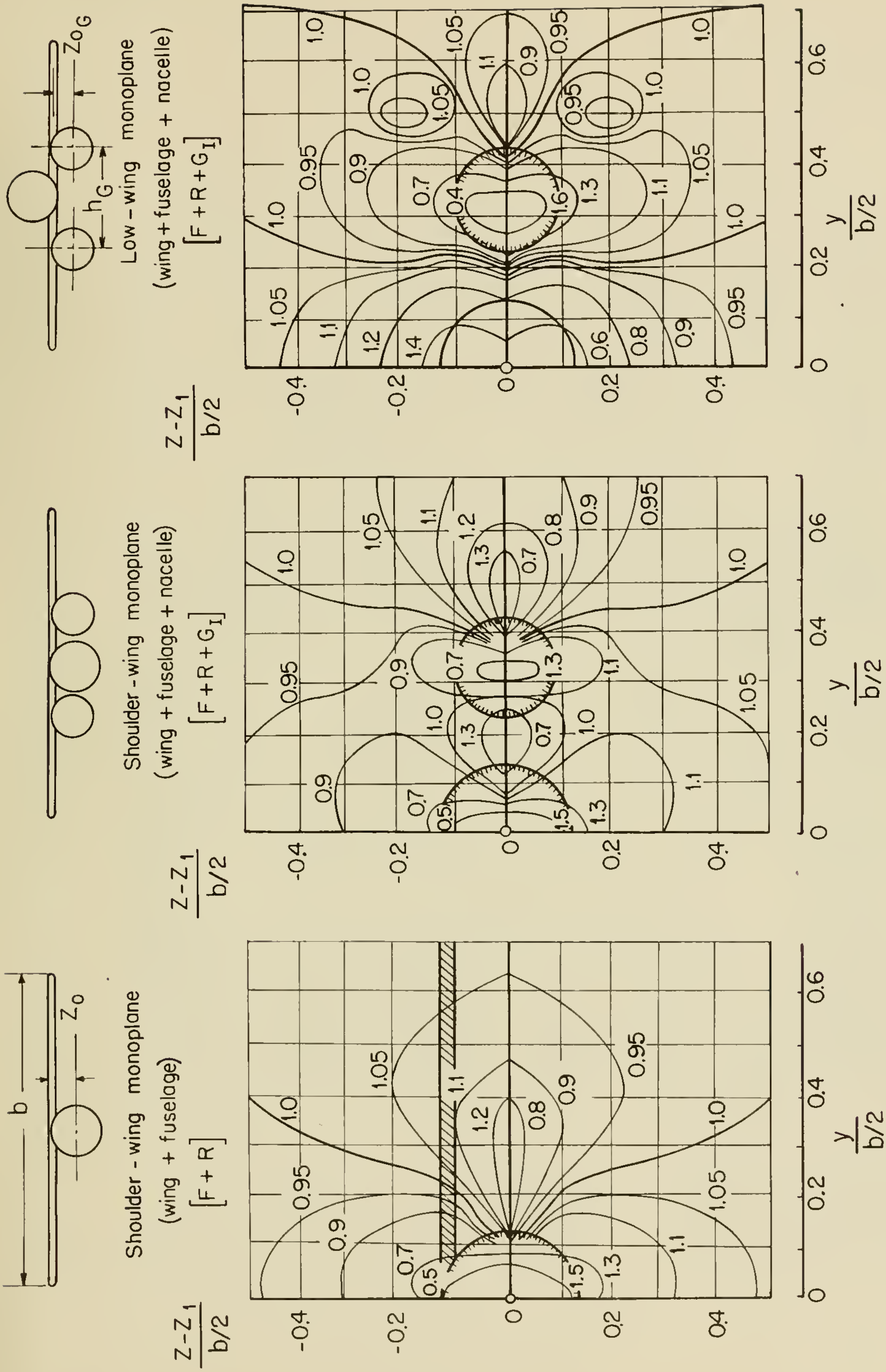


Figure 15.- Influence of the engine nacelles on the induced cross wind (theory).

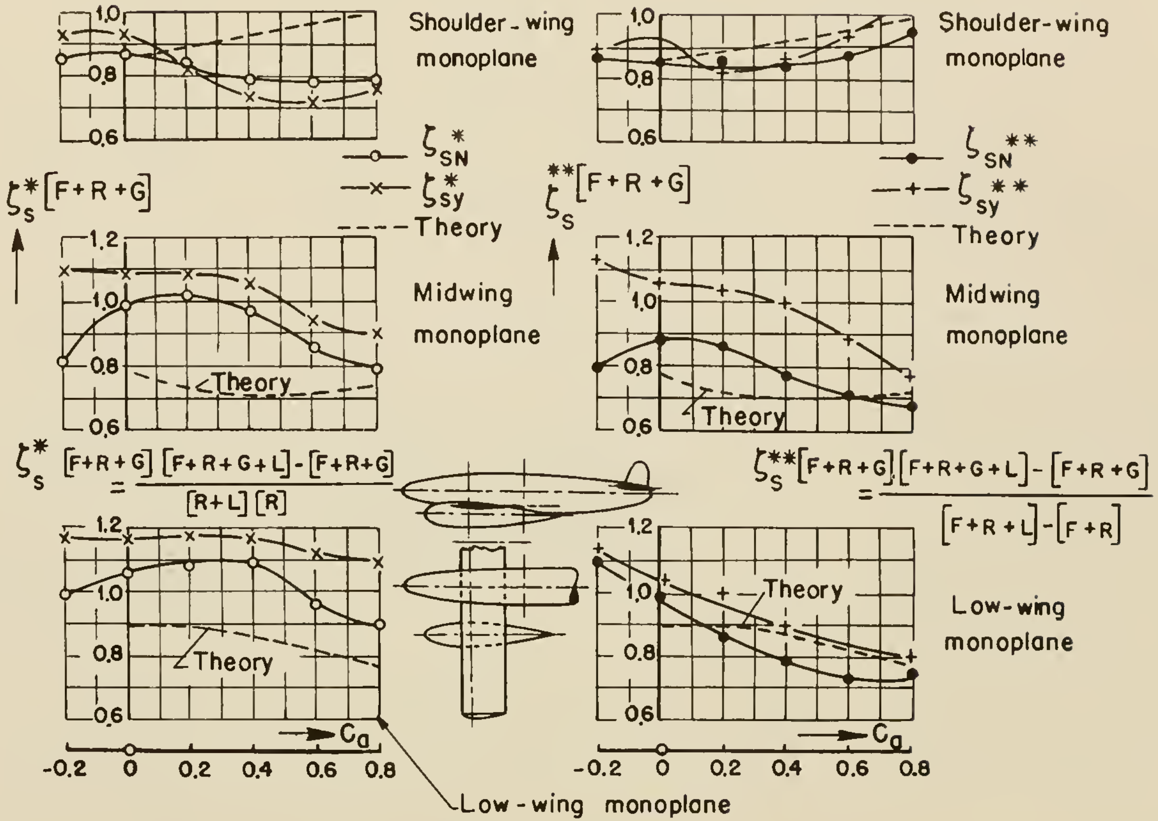


Figure 16.- Influence of the engine nacelles on the induced cross wind (directional stability). Comparison of theory and measurement.

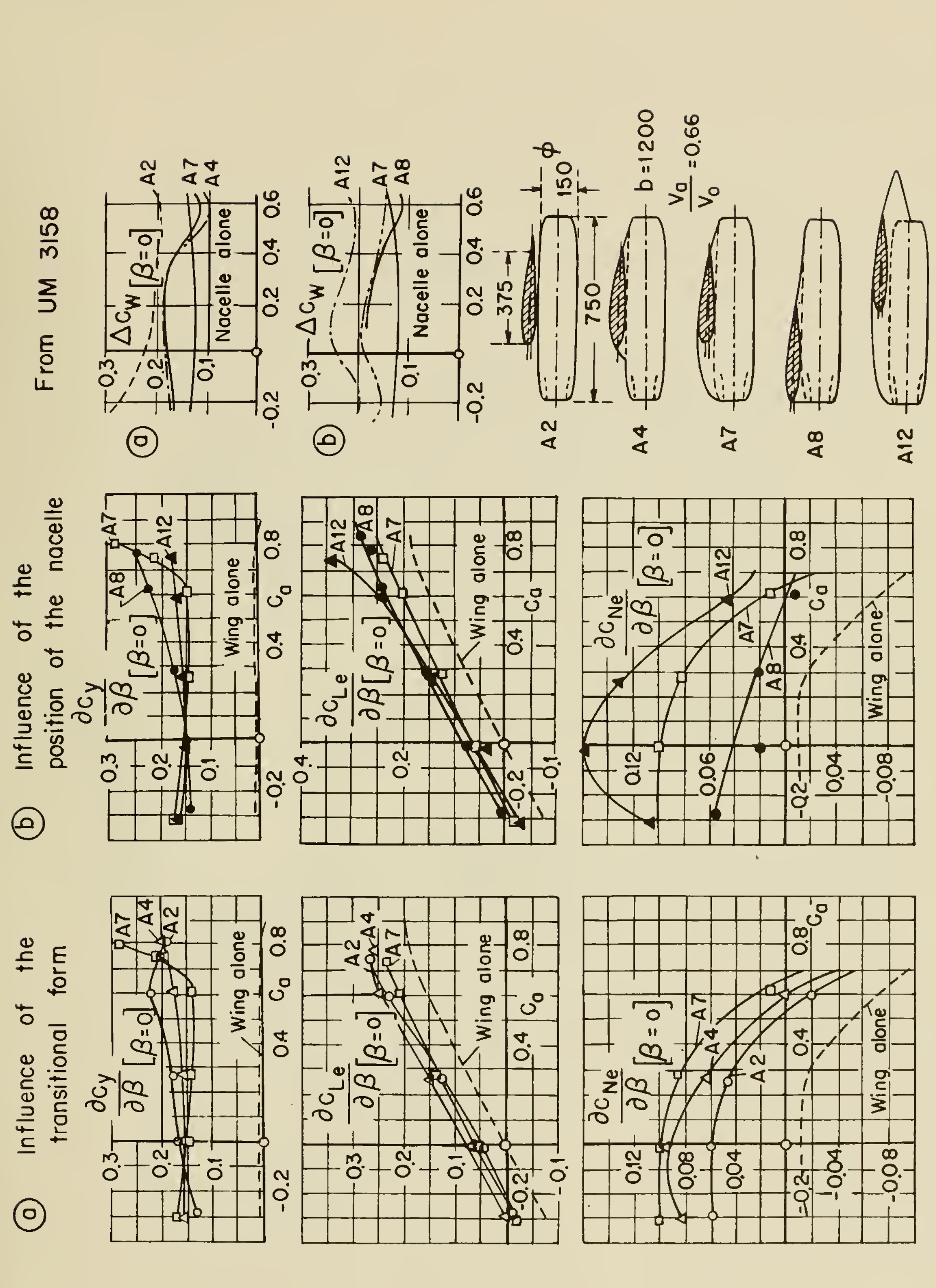


Figure 17.- Stability coefficients of an arrangement wing + jet nacelle.

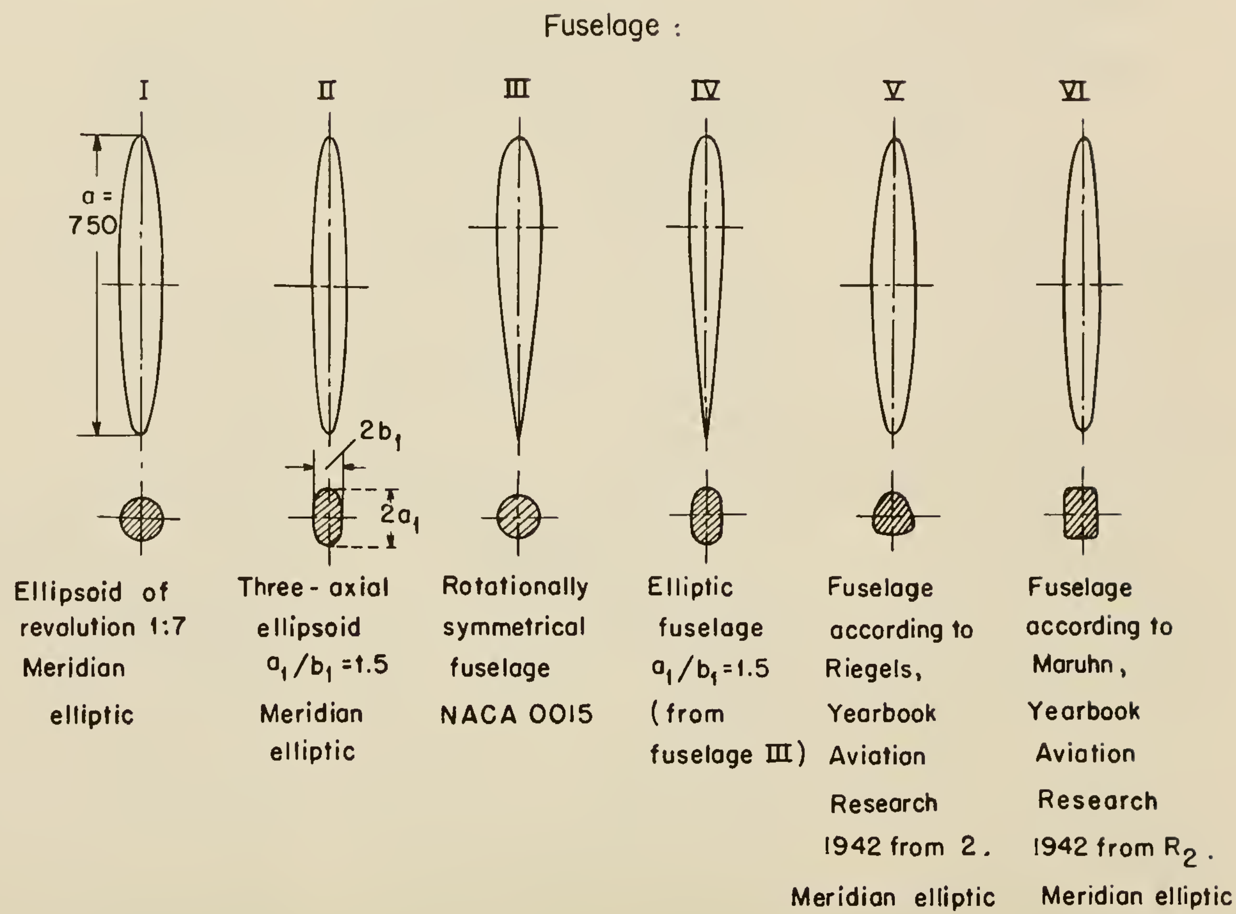


Figure 18.- Survey of the fuselages I to VI.

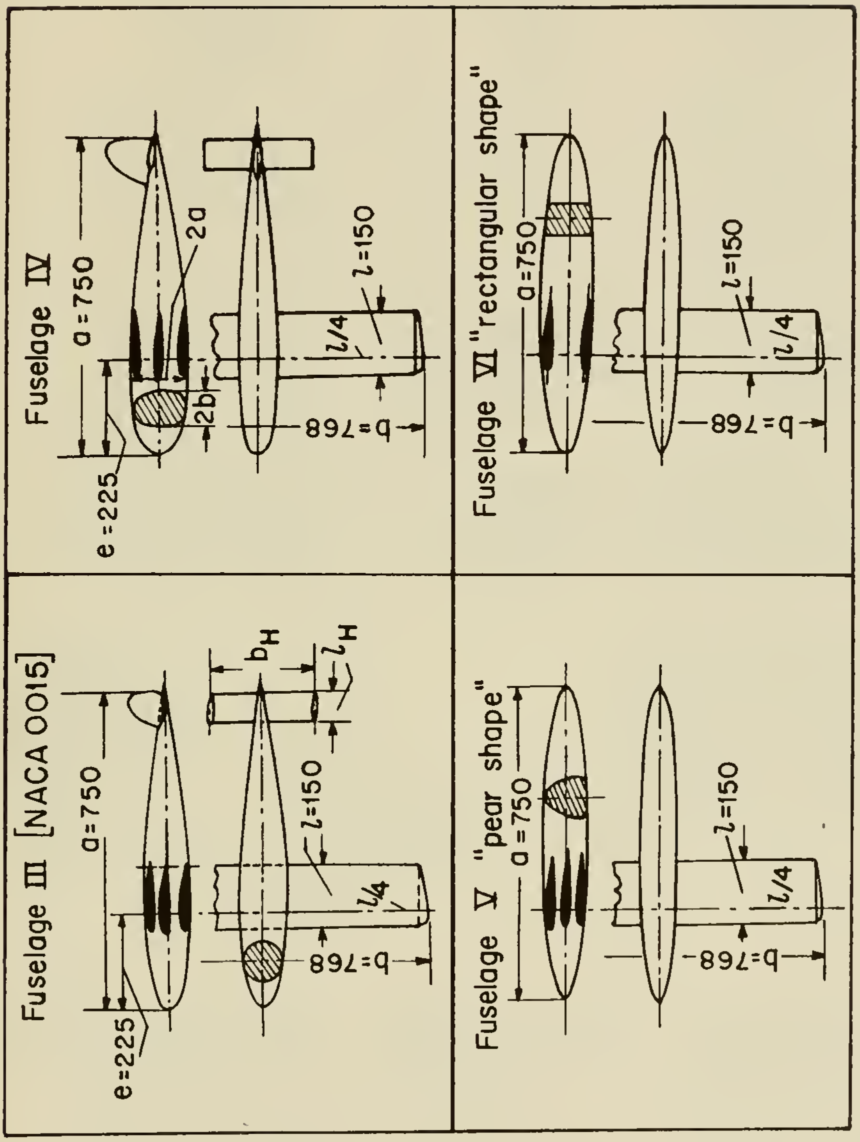
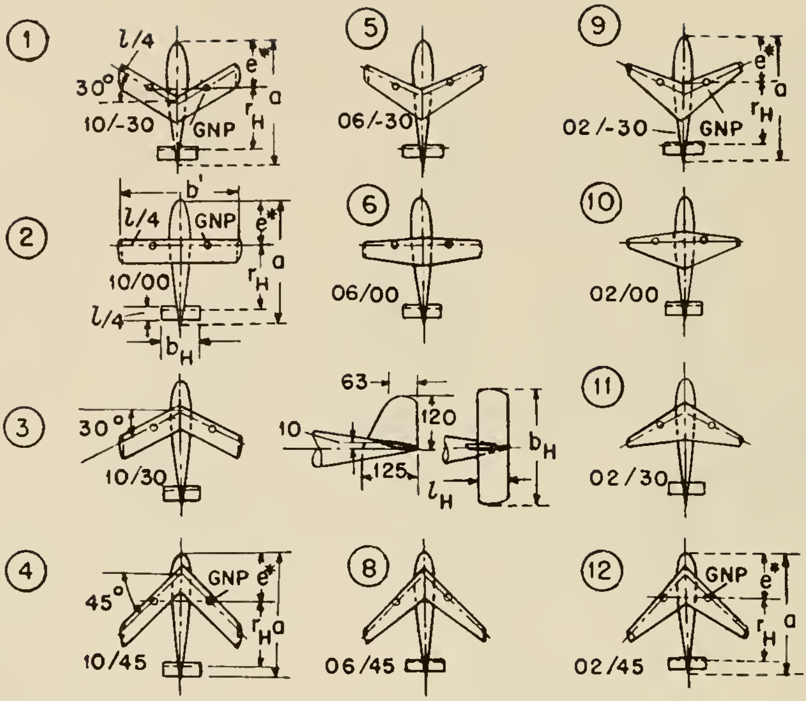


Figure 19.- Wing-fuselage arrangements with the fuselages III to VI.



Wing : profile NACA 23012

Fuselage : fuselage III (NACA 0015)

Tail unit : L I one-keeled

GNP = geometric neutral point of the wing

All models are midwing monoplanes

a = 0.750 m
b' = 0.750 m
e^* = 0.300 m
r_H = 0.3915 m
b_H = 0.250 m
L_H = 0.068 m

$\boxed{e^*/a = 0.4}$

Figure 20.- Aerodynamic-center program for wing-fuselage arrangements with sweepback.

NACA TM 1347
National Advisory Committee for Aeronautics.
REPORT ON THE SPECIAL FIELD "INTERFERENCE" TO THE WIND-TUNNEL COMMITTEE IN FEBRUARY 1945. (Bericht über das Fachgebiet Interferenz vor dem Windkanalausschuss im Februar 1945). H. Schlichting. Includes: Compilation of Interference Systematics at the Aerodynamic Institute of the Technical Academy Braunschweig. E. Moller. May 1953. 46p. diagrs. (NACA TM 1347. Trans. from Technische Hochschule Braunschweig. Aerodynamisches Institut. Bericht 45/4)

Contains an outline of investigations dealing with interference effects on the static stability of various airplane configurations that were conducted, were being conducted, and were started at the time of this present report. Results of several investigations are presented and discussed briefly. A supplement is attached showing the configurations

Copies obtainable from NACA, Washington (over)

1. Wing-Nacelle Combinations - Airplanes (1.7.1.1.2)
2. Tail-Wing and Fuselage Combinations - Airplanes (1.7.1.1.3)
3. Stability, Static (1.8.1.1)

I. Schlichting, Hermann
II. Moller, Egon
III. NACA TM 1347
IV. Technische Hochschule Braunschweig. Aerodynamisches Institut Bericht 45/4

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I. Schlichting, Hermann
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IV. Technische Hochschule Braunschweig. Aerodynamisches Institut Bericht 45/4

NACA TM 1347

tested and outlining the various test programs. Suggestions for future investigations are also included.

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1. Wing-Nacelle Combinations - Airplanes (1. 7. 1. 1. 2)
2. Tail-Wing and Fuselage Combinations - Airplanes (1. 7. 1. 1. 3)
3. Stability, Static (1. 8. 1. 1)

I. Schlichting, Hermann
II. Moller, Egon
III. NACA TM 1347
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Contains an outline of investigations dealing with interference effects on the static stability of various airplane configurations that were conducted, were being conducted, and were started at the time of this present report. Results of several investigations are presented and discussed briefly. A supplement is attached showing the configurations

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2. Tail-Wing and Fuselage Combinations - Airplanes (1. 7. 1. 1. 3)
3. Stability, Static (1. 8. 1. 1)

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